Why Program?

Chapter 1

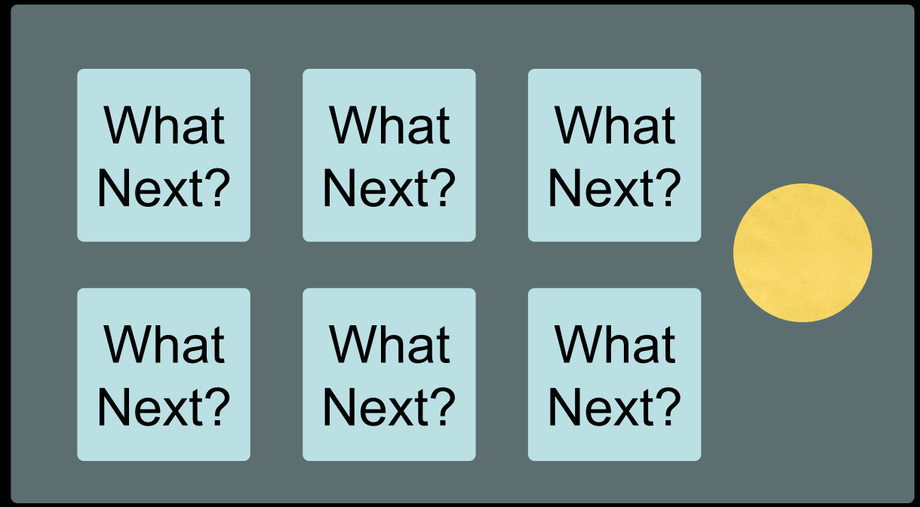
Python for Everybody

www.py4e.com

Computers Want to be Helpful...

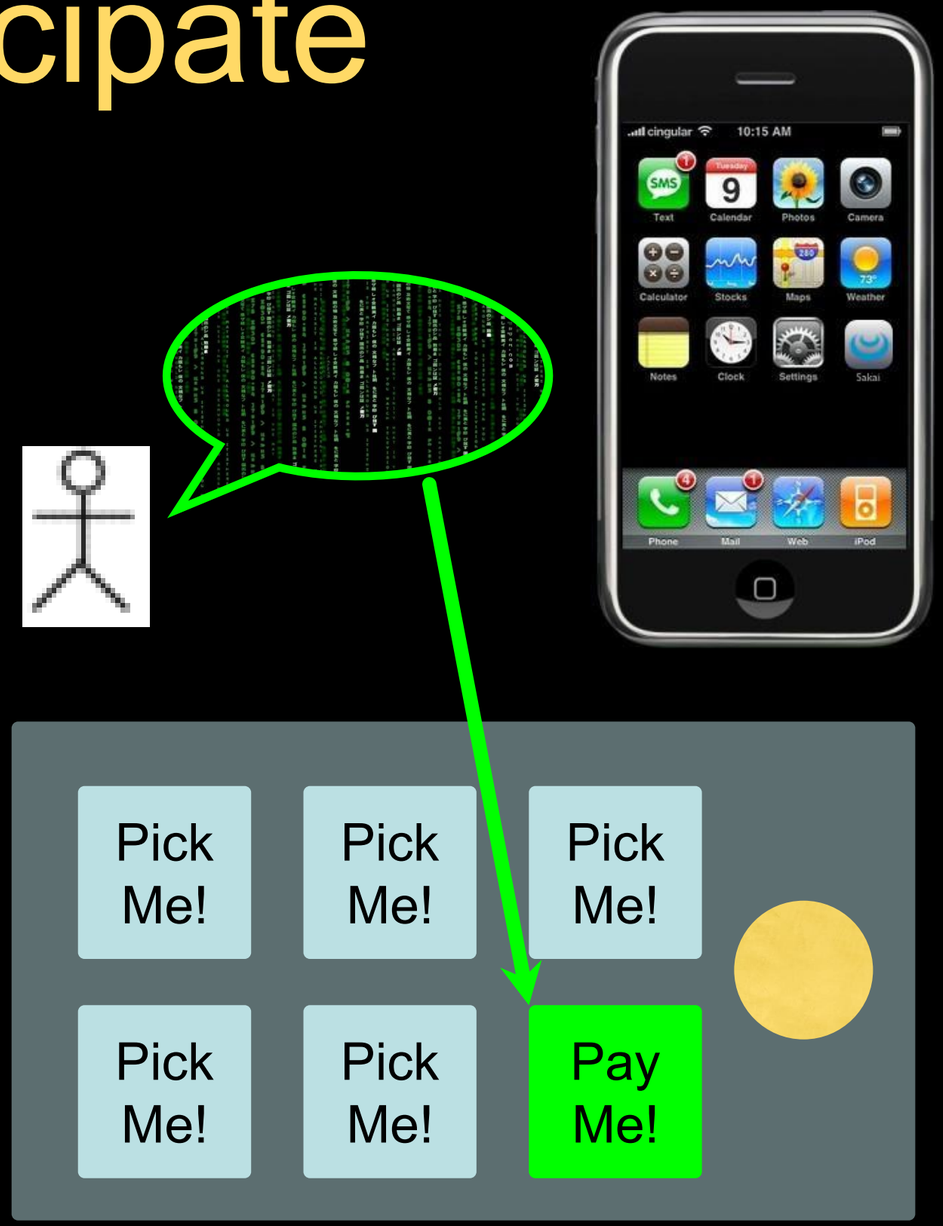
- Computers are built for one purpose - to do things for us
- But we need to speak their language to describe what we want done
- Users have it easy - someone already put many different programs (instructions) into the computer and users just pick the ones they want to use

What Next?



Programmers Anticipate Needs

- iPhone applications are a market
- iPhone applications have over 3 billion downloads
- Programmers have left their jobs to be full-time iPhone developers
- Programmers know the ways of the program

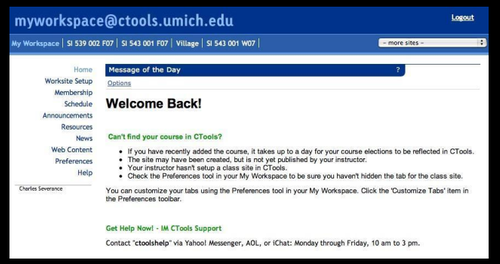


Users vs. Programmers

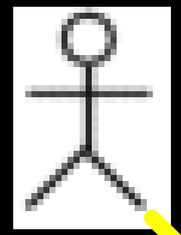
- Users see computers as a set of tools - word processor, spreadsheet, map, to-do list, etc.
- Programmers learn the computer “ways” and the computer language
- Programmers have some tools that allow them to build new tools
- Programmers sometimes write tools for lots of users and sometimes programmers write little “helpers” for themselves to automate a task

Why be a Programmer?

- To get some task done - we are the user and programmer
  - Clean up survey data
- To produce something for others to use - a programming job
  - Fix a performance problem in the Sakai software
  - Add a guestbook to a web site


myworkspace@ctools.umich.edu
Logout
My Workspace | SI 539 002 F07 | SI 543 001 F07 | Village | SI 543 001 W07 | - more sites -
Home
Worksite Setup
Membership
Schedule
Announcements
Resources
News
Web Content
Preferences
Help
Charles Severance
Message of the Day
Options
Welcome Back!
Can't find your course in CTools?
If you have recently added the course, it takes up to a day for your course elections to be reflected in CTools.
The site may have been created, but is not yet published by your instructor.
Your instructor hasn't setup a class site in CTools.
Check the Preferences tool in your My Workspace to be sure you haven't hidden the tab for the class site.
You can customize your tabs using the Preferences tool in your My Workspace. Click the 'Customize Tabs' item in the Preferences toolbar.
Get Help Now! - IM CTools Support
Contact "ctoolshelp" via Yahoo! Messenger, AOL, or iChat: Monday through Friday, 10 am to 3 pm.

User



Computer
Hardware + Software

Programmer

Data

Information

....

Networks

From a software creator's point of view, we build the software. The end users (stakeholders/actors) are our masters - who we want to please - often they pay us money when they are pleased. But the data, information, and networks are our problem to solve on their behalf. The hardware and software are our friends and allies in this quest.

What is Code? Software? A Program?

- A sequence of stored instructions

  - It is a little piece of our intelligence in the computer

  - We figure something out and then we encode it and then give it to someone else to save them the time and energy of figuring it out

- A piece of creative art - particularly when we do a good job on user experience

Programs for Humans...

https://www.youtube.com/watch?v=XiBYM6g8Tck

Programs for Humans...

while music is playing:
- Left hand out and up
- Right hand out and up
- Flip Left hand
- Flip Right hand
- Left hand to right shoulder
- Right hand to left shoulder
- Left hand to back of head
- Right ham to back of head
- Left hand to right hit
- Right hand to left hit
- Left hand on left bottom
- Right hand on right bottom
- Wiggle
- Wiggle
- Jump

https://www.youtube.com/watch?v=XiBYM6g8Tck

Programs for Humans...

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- Right hand to left shoulder
- Left hand to back of head
- Right hand to back of head
- Left hand to right hip
- Right hand to left hip
- Left hand on left bottom
- Right hand on right bottom
- Wiggle
- Wiggle
- Jump

https://www.youtube.com/watch?v=XiBYM6g8Tck

Programs for Python...

the clown ran after the car and the car ran into the tent and
the tent fell down on the clown and the car

Image: https://www.flickr.com/photos/allan_harris/4908070612/ Attribution-NoDerivs 2.0 Generic (CC BY-ND 2.0)

Programs for Python...

Image: https://www.flickr.com/photos/allan_harris/4908070612/ Attribution-NoDerivs 2.0 Generic (CC BY-ND 2.0)

```
name = input('Enter file:')
handle = open(name)

counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

print(bigword, bigcount)
```

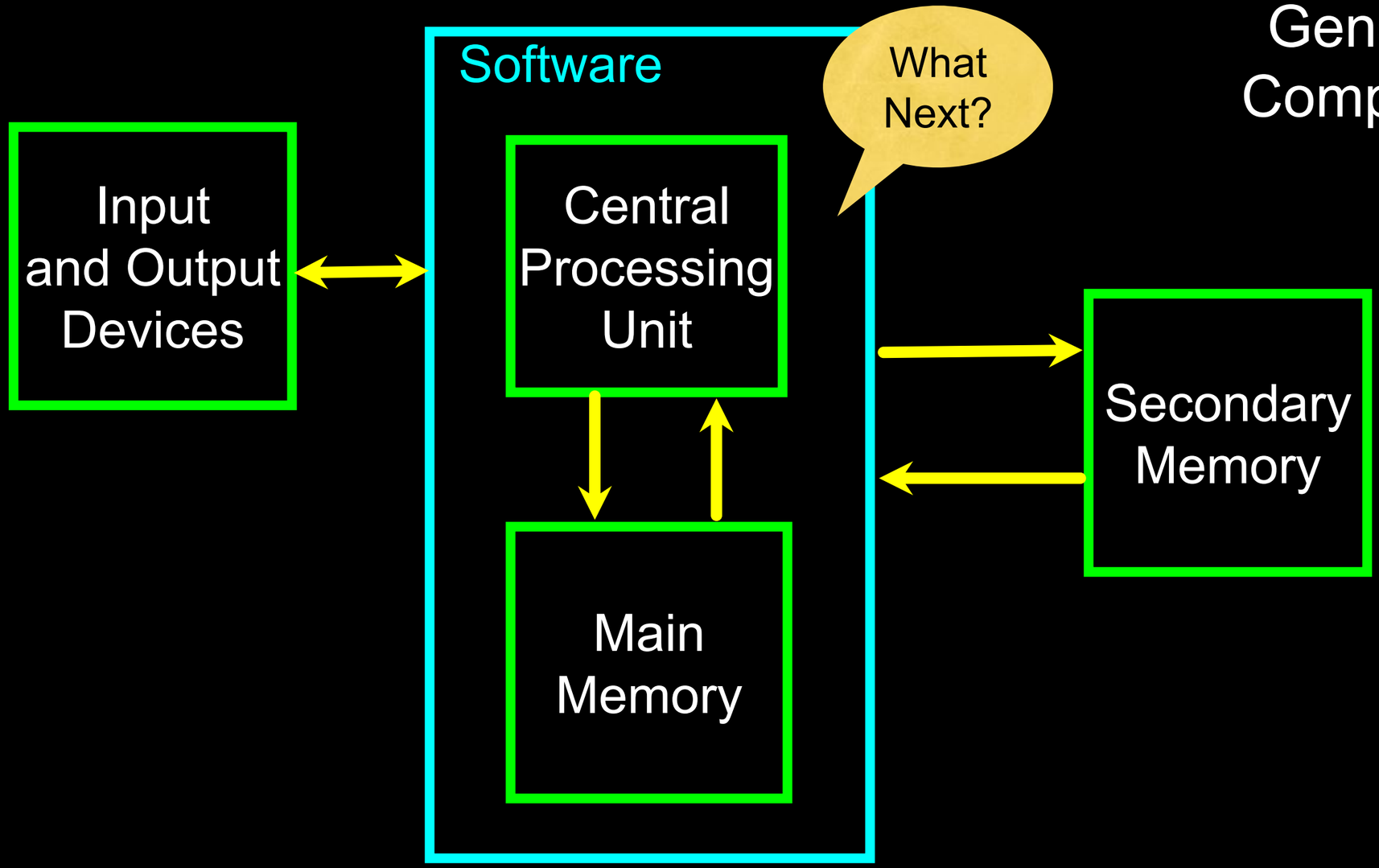
```
python words.py
Enter file: words.txt
to 16
```

```
python words.py
Enter file: clown.txt
the 7
```

Hardware Architecture

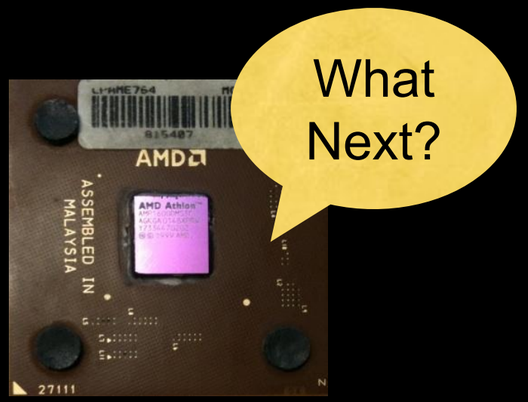
http://upload.wikimedia.org/wikipedia/commons/3/3d/RaspberryPi.jpg

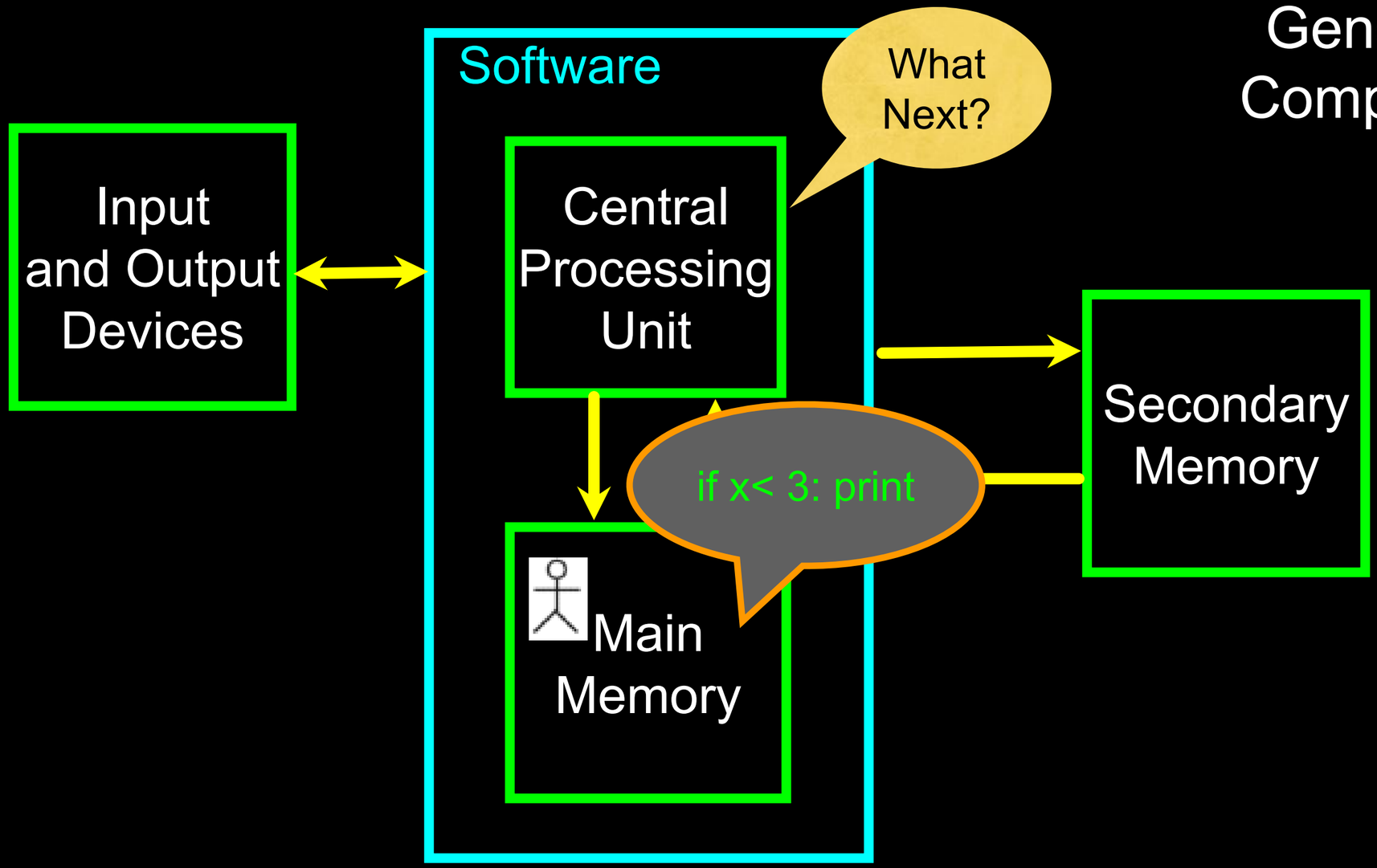
Generic Computer

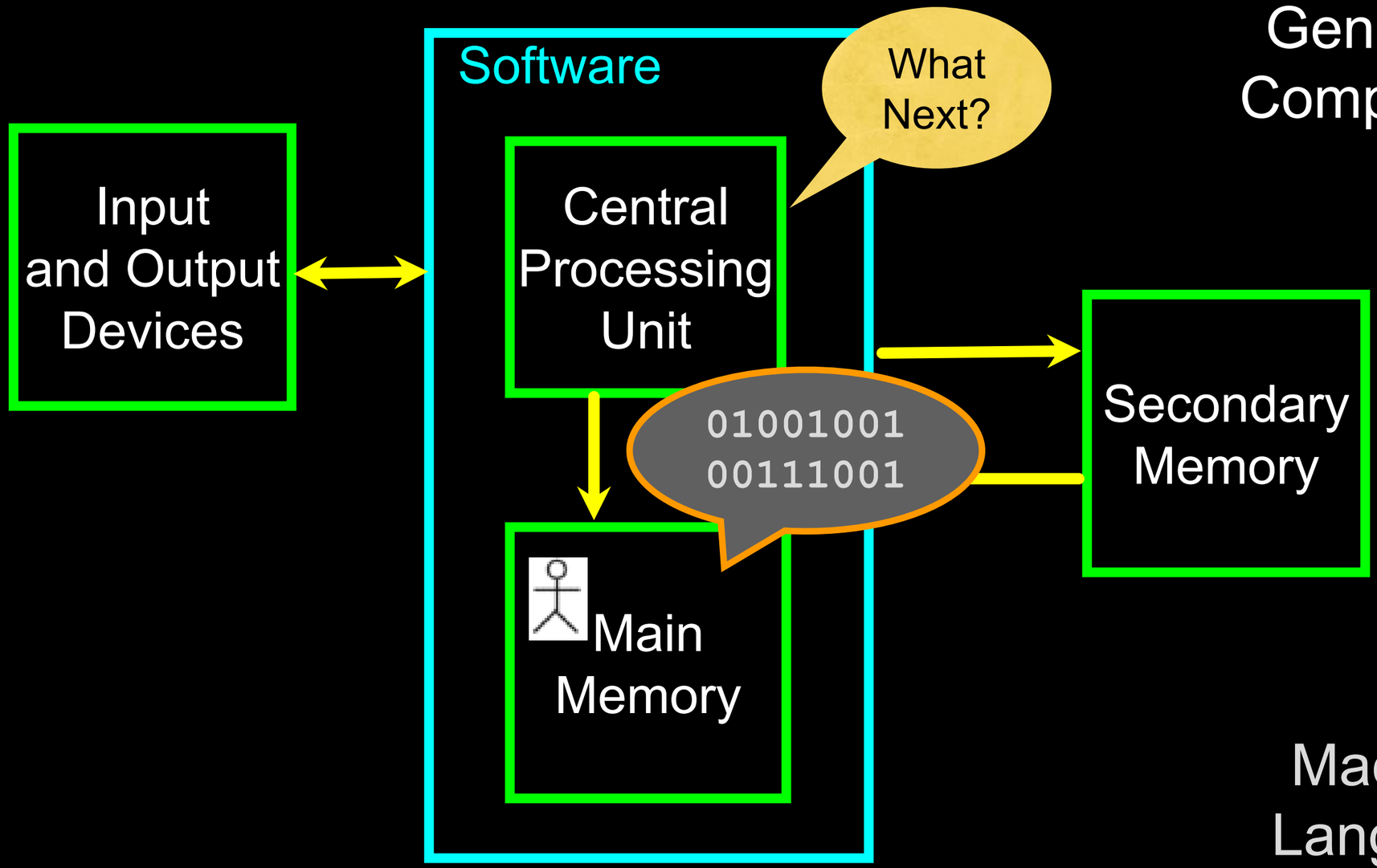


Definitions

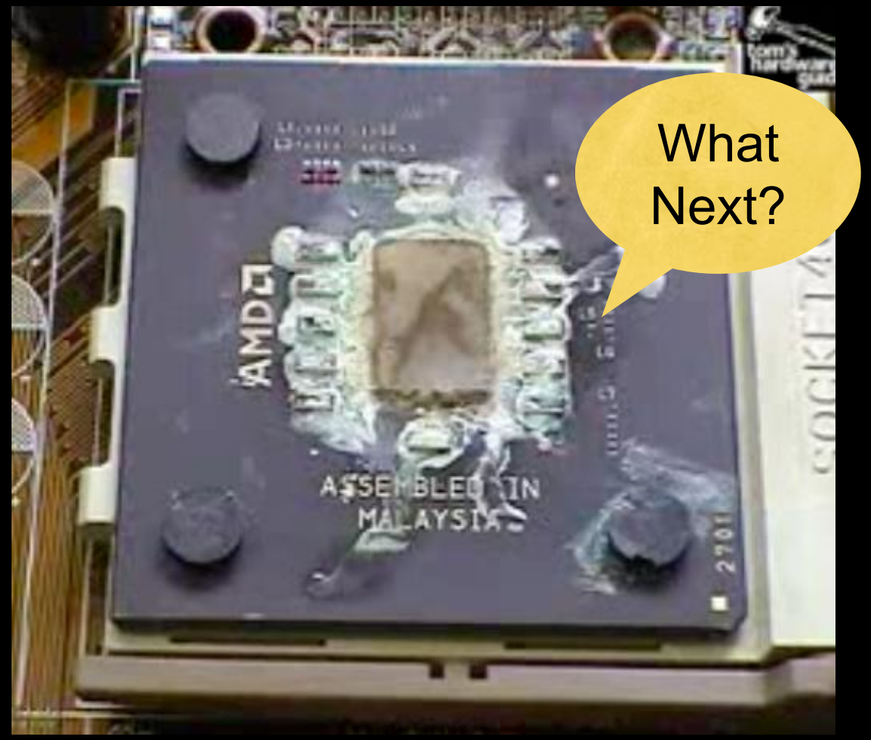
- Central Processing Unit: Runs the Program - The CPU is always wondering “what to do next”. Not the brains exactly - very dumb but very very fast
- Input Devices: Keyboard, Mouse, Touch Screen
- Output Devices: Screen, Speakers, Printer, DVD Burner
- Main Memory: Fast small temporary storage - lost on reboot - aka RAM
- Secondary Memory: Slower large permanent storage - lasts until deleted - disk drive / memory stick




Generic
Computer
Software
What
Next?
Input
and Output
Devices
Central
Processing
Unit
Secondary
Memory
if x< 3: print
Main
Memory


Generic
Computer
Software
What
Next?
Input
and Output
Devices
Central
Processing
Unit
01001001
00111001
Secondary
Memory
Main
Memory
Machine
Language

Totally Hot CPU



http://www.youtube.com/watch?v=y39D4529FM4

Hard Disk in Action

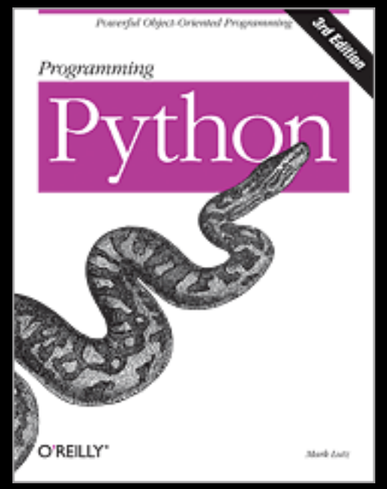
http://www.youtube.com/watch?v=9eMWG3fwiEU

Python as a Language

Parseltongue is the language of serpents and those who can converse with them. An individual who can speak Parseltongue is known as a Parselmouth. It is a very uncommon skill, and may be hereditary. Nearly all known Parselmouths are descended from Salazar Slytherin.

http://harrypotter.wikia.com/wiki/Parseltongue

Python is the language of the Python Interpreter and those who can converse with it. An individual who can speak Python is known as a Pythonista. It is a very uncommon skill, and may be hereditary. Nearly all known Pythonistas use software initially developed by Guido van Rossum.



Early Learner: Syntax Errors

- We need to learn the Python language so we can communicate our instructions to Python. In the beginning we will make lots of mistakes and speak gibberish like small children.

- When you make a mistake, the computer does not think you are “cute”. It says “syntax error” - given that it knows the language and you are just learning it. It seems like Python is cruel and unfeeling.

- You must remember that you are intelligent and can learn. The computer is simple and very fast, but cannot learn. So it is easier for you to learn Python than for the computer to learn English...

Talking to Python

```
csev$ python3
Python 3.5.1 (v3.5.1:37a07cee5969, Dec  5 2015, 21:12:44)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwinType
"help", "copyright", "credits" or "license" for more information.
>>>
```

What next?

```
csev$ python3
Python 3.5.1 (v3.5.1:37a07cee5969, Dec  5 2015, 21:12:44)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwinType
"help", "copyright", "credits" or "license" for more information.
>>> x = 1
>>> print(x)
1
>>> x = x + 1
>>> print(x)
2
>>> exit()
```

This is a good test to make sure that you have Python correctly installed. Note that quit() also works to end the interactive session.

What Do We Say?

Elements of Python

- Vocabulary / Words - Variables and Reserved words (Chapter 2)
- Sentence structure - valid syntax patterns (Chapters 3-5)
- Story structure - constructing a program for a purpose

```
name = input('Enter file:')
handle = open(name)

counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

print(bigword, bigcount)
```

A short “story” about how to count words in a file in Python

```
python words.py
Enter file: words.txt
to 16
```

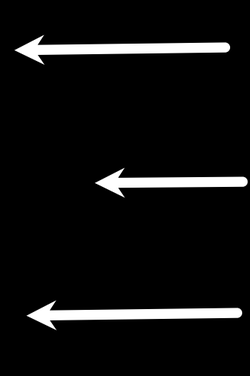
Reserved Words

You cannot use reserved words as variable names / identifiers

```
False      await      else       import     pass
None       break      except     in         raise
True       class      finally    is         return
and        continue   for        lambda     try
as         def        from       nonlocal   while
assert     del        global     not        with
async      elif       if         or         yield
```

Sentences or Lines

```
x = 2
x = x + 2
print(x)
```



Assignment statement

Assignment with expression

Print statement

Variable Operator Constant Function

Programming Paragraphs

Python Scripts

- Interactive Python is good for experiments and programs of 3-4 lines long.
- Most programs are much longer, so we type them into a file and tell Python to run the commands in the file.
- In a sense, we are “giving Python a script”.
- As a convention, we add “.py” as the suffix on the end of these files to indicate they contain Python.

Interactive versus Script

- Interactive

  - You type directly to Python one line at a time and it responds

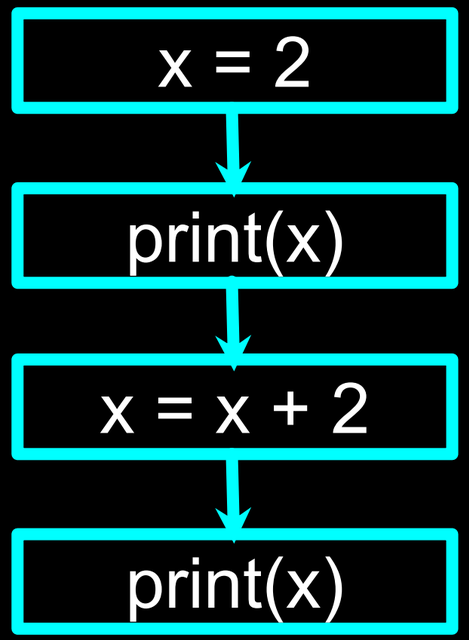
- Script

  - You enter a sequence of statements (lines) into a file using a text editor and tell Python to execute the statements in the file

Program Steps or Program Flow

- Like a recipe or installation instructions, a program is a sequence of steps to be done in order.
- Some steps are conditional - they may be skipped.
- Sometimes a step or group of steps is to be repeated.
- Sometimes we store a set of steps to be used over and over as needed several places throughout the program (Chapter 4).

Sequential Steps



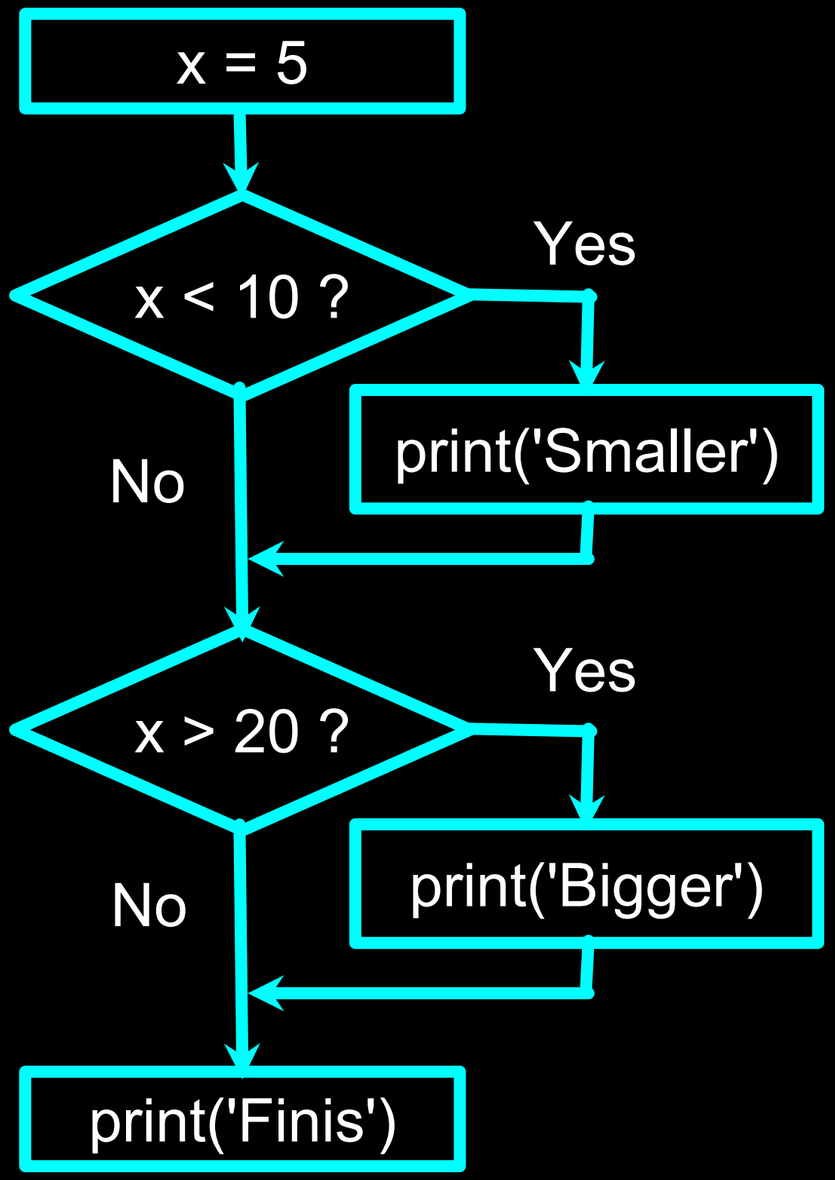
Program:

```
x = 2
print(x)
x = x + 2
print(x)
```

Output:

```
2
4
```

When a program is running, it flows from one step to the next. As programmers, we set up “paths” for the program to follow.



Conditional Steps

Program:

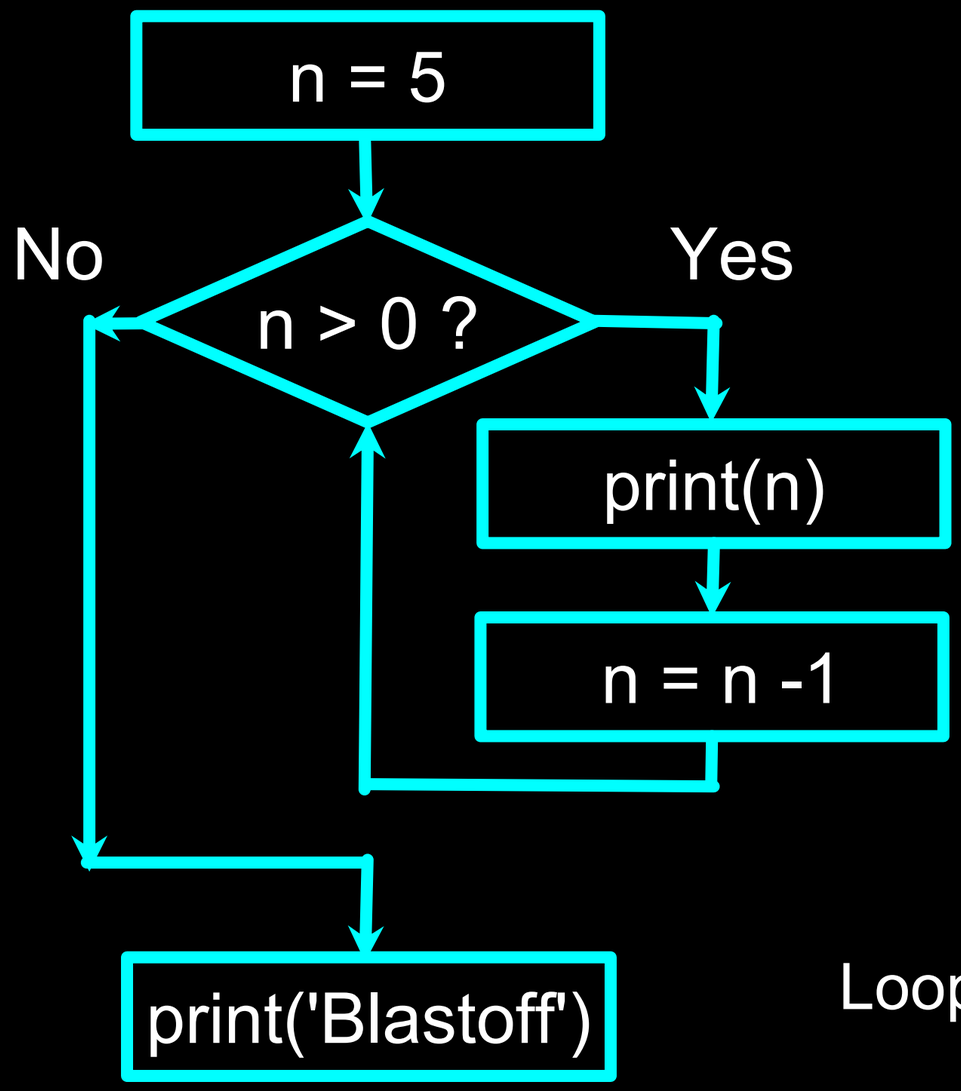
```
x = 5
if x < 10:
    print('Smaller')
if x > 20:
    print('Bigger')

print('Finis')
```

Output:

```
Smaller
Finis
```

Repeated Steps



Program:

```
n = 5
while n > 0 :
    print(n)
    n = n - 1
print('Blastoff!')
```

Output:

```
5
4
3
2
1
Blastoff!
```

Loops (repeated steps) have iteration variables that change each time through a loop.

```
name = input('Enter file:')
handle = open(name, 'r')

counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

print(bigword, bigcount)
```

Sequential

Repeated

Conditional

```
name = input('Enter file:')
handle = open(name, 'r')

counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

print(bigword, bigcount)
```

A short Python “Story” about how to count words in a file

A word used to read data from a user

A sentence about updating one of the many counts

A paragraph about how to find the largest item in a list

Summary

- This is a quick overview of Chapter 1
- We will revisit these concepts throughout the course
- Focus on the big picture

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translators here

Continue…

Variables, Expressions, and Statements

Chapter 2

Python for Everybody

www.py4e.com

Constants

- Fixed values such as numbers, letters, and strings, are called “constants” because their value does not change
- Numeric constants are as you expect
- String constants use single quotes (') or double quotes (")

```
>>> print(123)
123
>>> print(98.6)
98.6
>>> print('Hello world')
Hello world
```

Reserved Words

You cannot use reserved words as variable names / identifiers

```
False      await      else       import     pass
None       break      except     in         raise
True       class      finally    is         return
and        continue   for        lambda     try
as         def        from       nonlocal   while
assert     del        global     not        with
async      elif       if         or         yield
```

Variables

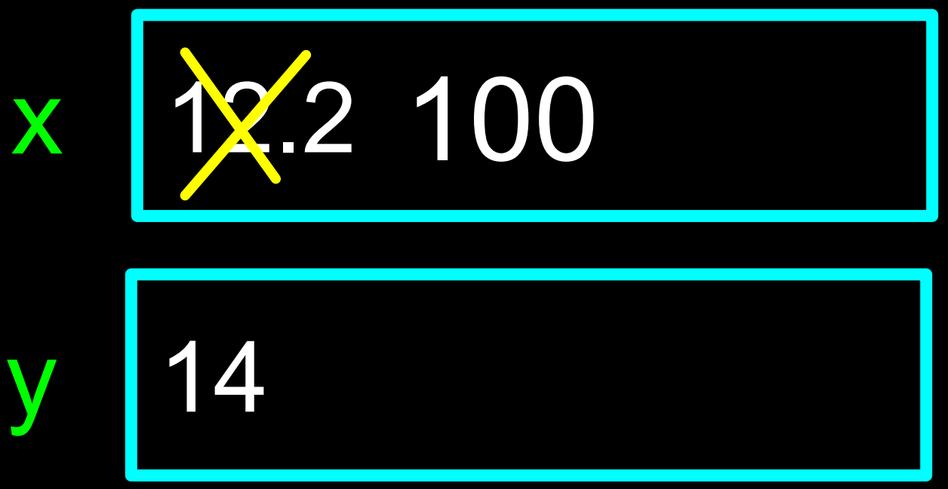
- A variable is a named place in the memory where a programmer can store data and later retrieve the data using the variable “name”
- Programmers get to choose the names of the variables
- You can change the contents of a variable in a later statement

```
x = 12.2
y = 14
```

Variables

- A variable is a named place in the memory where a programmer can store data and later retrieve the data using the variable “name”
- Programmers get to choose the names of the variables
- You can change the contents of a variable in a later statement

```
x = 12.2
y = 14
x = 100
```



Python Variable Name Rules

- Must start with a letter or underscore _
- Must consist of letters, numbers, and underscores
- Case Sensitive

```
Good:      spam     eggs    spam23      _speed
Bad:       23spam       #sign   var.12
Different:      spam    Spam    SPAM
```

Mnemonic Variable Names

- Since we programmers are given a choice in how we choose our variable names, there is a bit of “best practice”
- We name variables to help us remember what we intend to store in them (“mnemonic” = “memory aid”)
- This can confuse beginning students because well-named variables often “sound” so good that they must be keywords

http://en.wikipedia.org/wiki/Mnemonic

```
x1q3z9ocd = 35.0
x1q3z9afd = 12.50
x1q3p9afd = x1q3z9ocd * x1q3z9afd
print(x1q3p9afd)
```

What is this bit of code doing?

```
x1q3z9ocd = 35.0
x1q3z9afd = 12.50
x1q3p9afd = x1q3z9ocd * x1q3z9afd
print(x1q3p9afd)
```

```
a = 35.0
b = 12.50
c = a * b
print(c)
```

What are these bits of code doing?

```
x1q3z9ocd = 35.0
x1q3z9afd = 12.50
x1q3p9afd = x1q3z9ocd * x1q3z9afd
print(x1q3p9afd)
```

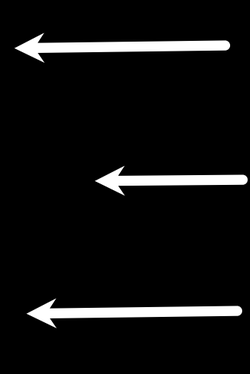
```
a = 35.0
b = 12.50
c = a * b
print(c)
```

What are these bits of code doing?

```
hours = 35.0
rate = 12.50
pay = hours * rate
print(pay)
```

Sentences or Lines

```
x = 2
x = x + 2
print(x)
```



Assignment statement

Assignment with expression

Print statement

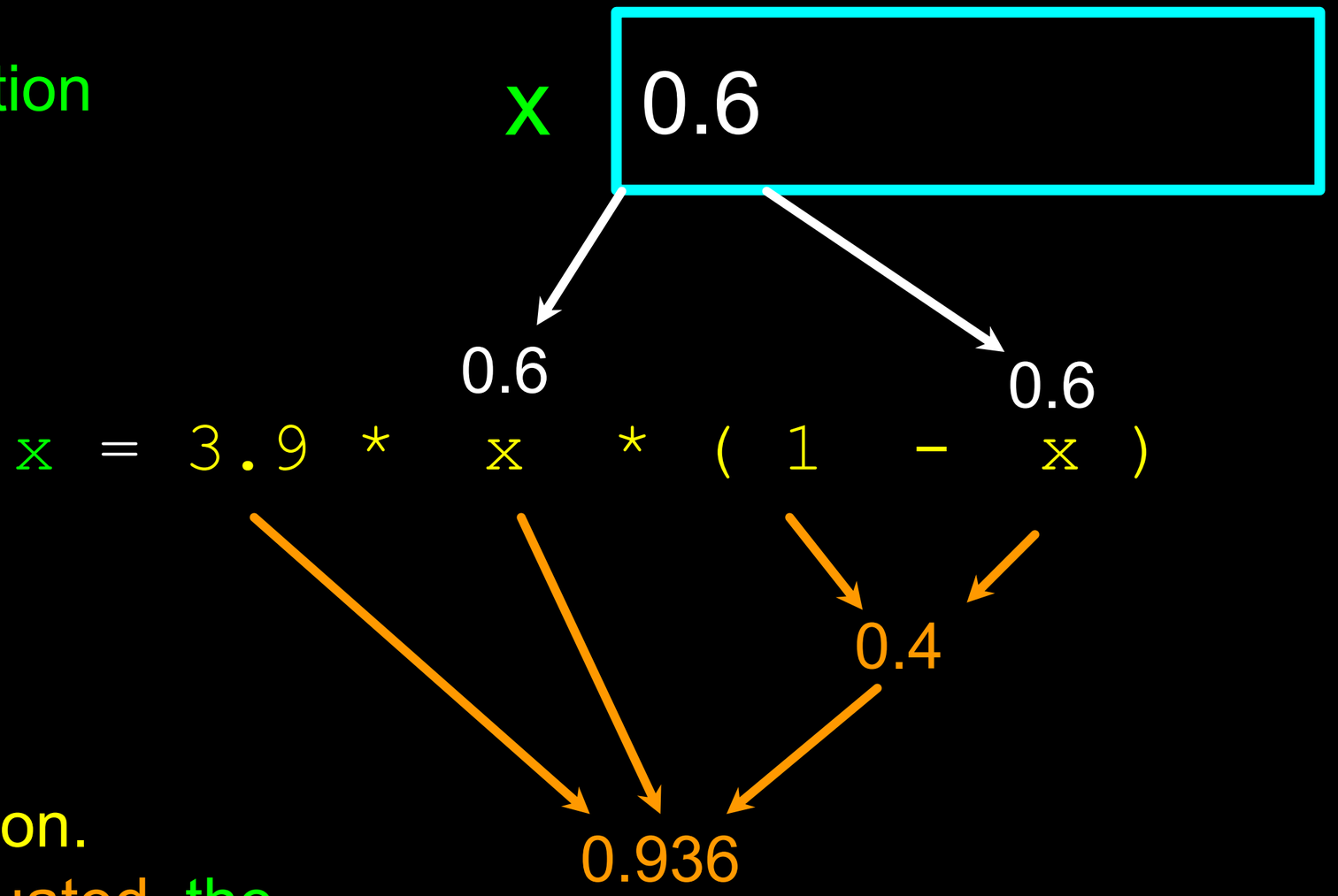
Variable Operator Constant Function

Assignment Statements

- We assign a value to a variable using the assignment statement (=)
- An assignment statement consists of an expression on the right-hand side and a variable to store the result

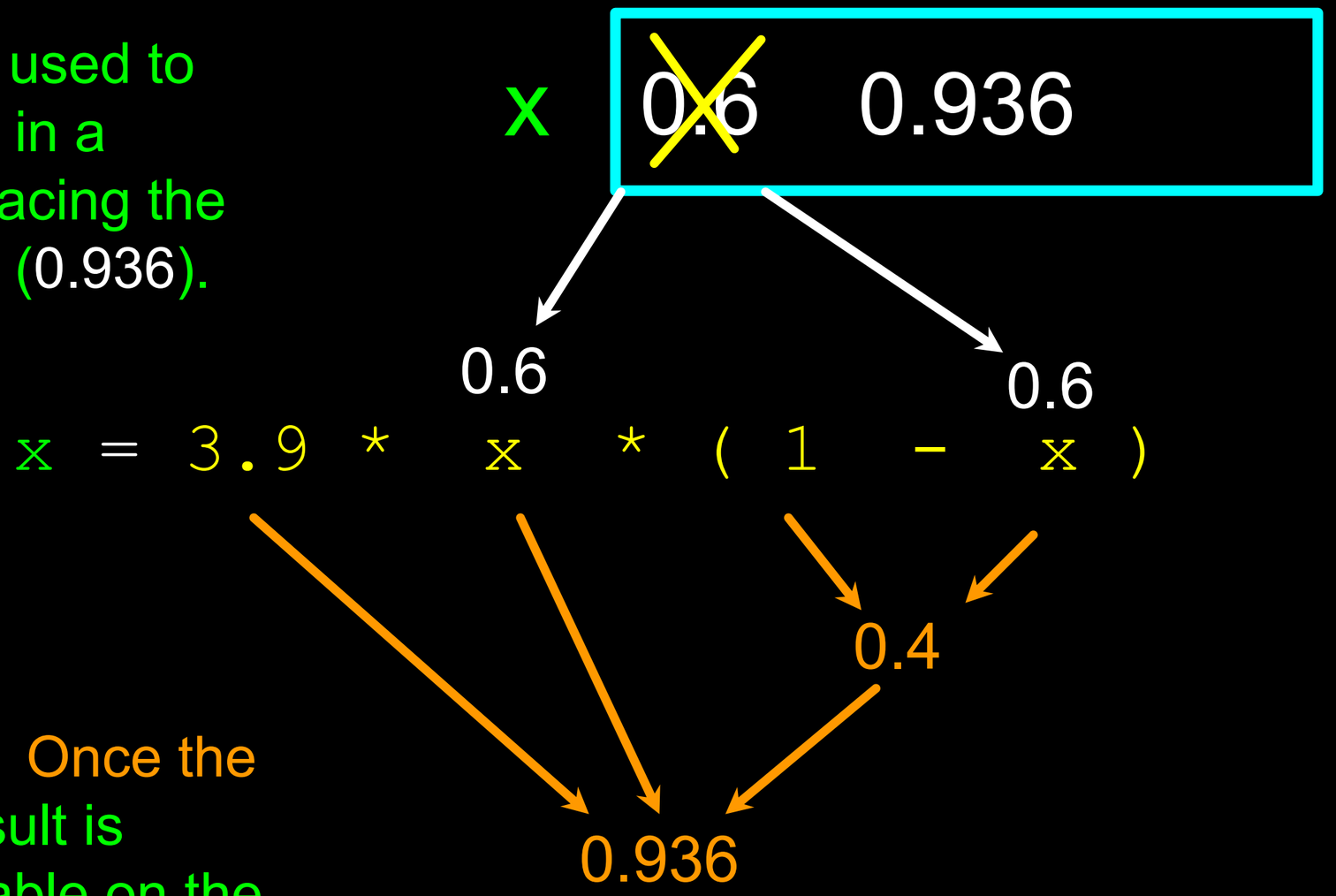
```
x = 3.9 * x * ( 1 - x )
```

A variable is a memory location
used to store a value (0.6)



The right side is an expression.
Once the expression is evaluated, the
result is placed in (assigned to) x.

A variable is a memory location used to store a value. The value stored in a variable can be updated by replacing the old value (0.6) with a new value (0.936).



The right side is an expression. Once the expression is evaluated, the result is placed in (assigned to) the variable on the left side (i.e., x).

Expressions…

Numeric Expressions

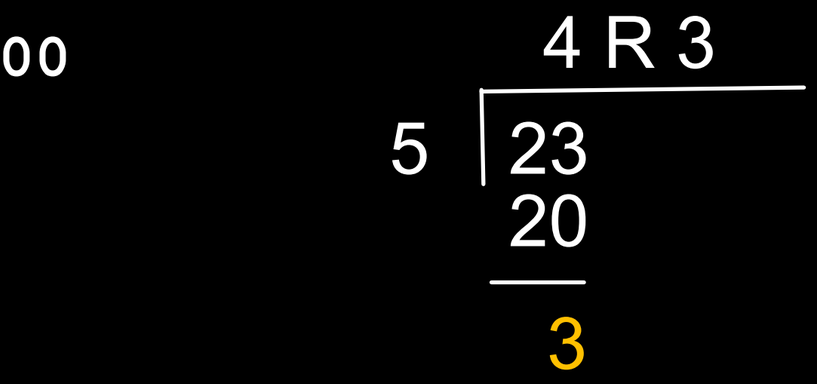
- Because of the lack of mathematical symbols on computer keyboards - we use “computer-speak” to express the classic math operations
- Asterisk is multiplication
- Exponentiation (raise to a power) looks different than in math

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Power
%	Remainder

Numeric Expressions

```
>>> xx = 2
>>> xx = xx + 2
>>> print(xx)
4
>>> yy = 440 * 12
>>> print(yy)
5280
>>> zz = yy / 1000
>>> print(zz)
5.28
```

```
>>> jj = 23
>>> kk = jj % 5
>>> print(kk)
3
>>> print(4 ** 3)
64
```



Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Power
%	Remainder

Order of Evaluation

- When we string operators together - Python must know which one to do first
- This is called “operator precedence”
- Which operator “takes precedence” over the others?

```
x = 1 + 2 * 3 - 4 / 5 ** 6
```

Operator Precedence Rules

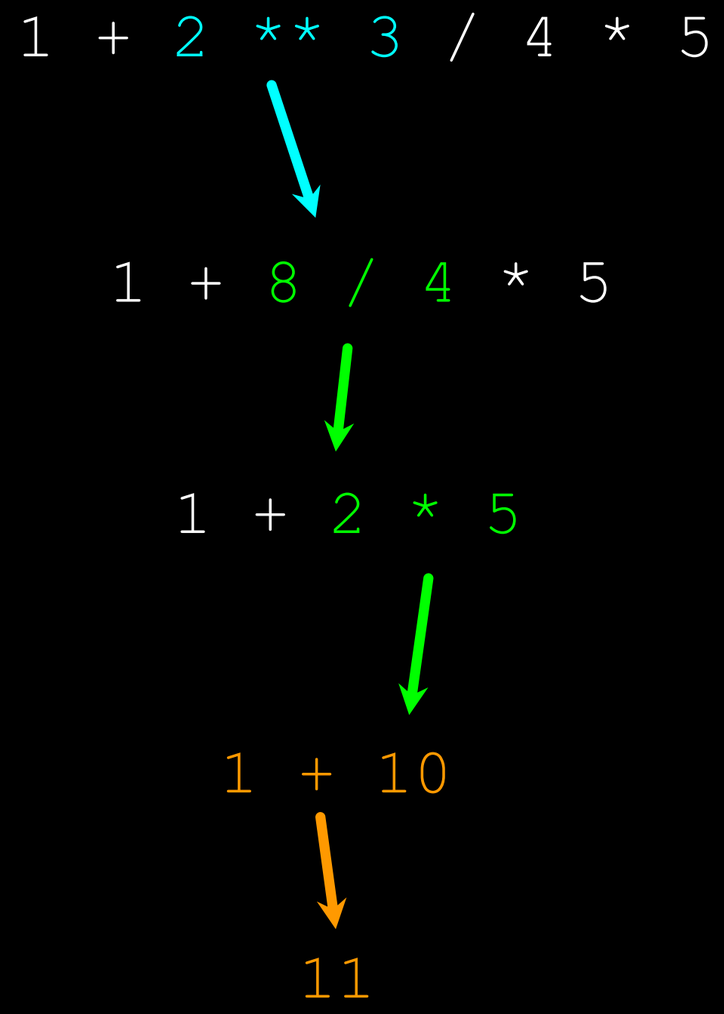
Highest precedence rule to lowest precedence rule:

- Parentheses are always respected
- Exponentiation (raise to a power)
- Multiplication, Division, and Remainder
- Addition and Subtraction
- Left to right

Parenthesis
Power
Multiplication
Addition
Left to Right

```
>>> x = 1 + 2 ** 3 / 4 * 5
>>> print(x)
11.0
>>>
```

Parenthesis
Power
Multiplication
Addition
Left to Right



Operator Precedence

Parenthesis
Power
Multiplication
Addition
Left to Right

- Remember the rules top to bottom
- When writing code - use parentheses
- When writing code - keep mathematical expressions simple enough that they are easy to understand
- Break long series of mathematical operations up to make them more clear

What Does “Type” Mean?

- In Python variables, literals, and constants have a “type”
- Python knows the difference between an integer number and a string
- For example “+” means “addition” if something is a number and “concatenate” if something is a string

```
>>> ddd = 1 + 4
>>> print(ddd)
5
>>> eee = 'hello ' + 'there'
>>> print(eee)
hello there
```

concatenate = put together

Type Matters

- Python knows what “type” everything is
- Some operations are prohibited
- You cannot “add 1” to a string
- We can ask Python what type something is by using the type() function

```
>>> eee = 'hello ' + 'there'
>>> eee = eee + 1
Traceback (most recent call last):
File "<stdin>", line 1, in
<module>
TypeError: can only concatenate
str (not "int") to str
>>> type(eee)
<class'str'>
>>> type('hello')
<class'str'>
>>> type(1)
<class'int'>
>>>
```

Several Types of Numbers

- Numbers have two main types

  - Integers are whole numbers:
    -14, -2, 0, 1, 100, 401233

  - Floating Point Numbers have
  decimal parts: -2.5 , 0.0, 98.6, 14.0

- There are other number types - they are variations on float and integer

```
>>> xx = 1
>>> type (xx)
<class 'int'>
>>> temp = 98.6
>>> type(temp)
<class'float'>
>>> type(1)
<class 'int'>
>>> type(1.0)
<class'float'>
>>>
```

Type Conversions

- When you put an integer and floating point in an expression, the integer is implicitly converted to a float
- You can control this with the built-in functions int() and float()

```
>>> print(float(99) + 100)
199.0
>>> i = 42
>>> type(i)
<class'int'>
>>> f = float(i)
>>> print(f)
42.0
>>> type(f)
<class'float'>
>>>
```

Integer Division

Integer division produces a floating point result

```
>>> print(10 / 2)
5.0
>>> print(9 / 2)
4.5
>>> print(99 / 100)
0.99
>>> print(10.0 / 2.0)
5.0
>>> print(99.0 / 100.0)
0.99
```

This was different in Python 2.x

String Conversions

- You can also use int() and float() to convert between strings and integers
- You will get an error if the string does not contain numeric characters

```
>>> sval = '123'
>>> type(sval)
<class 'str'>
>>> print(sval + 1)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: can only concatenate str
(not "int") to str
>>> ival = int(sval)
>>> type(ival)
<class 'int'>
>>> print(ival + 1)
124
>>> nsv = 'hello bob'
>>> niv = int(nsv)
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
ValueError: invalid literal for int()
with base 10: 'x'
```

User Input

- We can instruct Python to pause and read data from the user using the input() function
- The input() function returns a string

```
nam = input('Who are you? ')
print('Welcome', nam)
```

Who are you? Chuck
Welcome Chuck

Converting User Input

- If we want to read a number from the user, we must convert it from a string to a number using a type conversion function
- Later we will deal with bad input data

```
inp = input('Europe floor?')
usf = int(inp) + 1
print('US floor', usf)
```

Europe floor? 0
US floor 1

Comments in Python

- Anything after a # is ignored by Python
- Why comment?
  - Describe what is going to happen in a sequence of code
  - Document who wrote the code or other ancillary information
  - Turn off a line of code - perhaps temporarily

```
# Get the name of the file and open it
name = input('Enter file:')
handle = open(name, 'r')

# Count word frequency
counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

# Find the most common word
bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

# All done
print(bigword, bigcount)
```

Summary

- Type
- Reserved words
- Variables (mnemonic)
- Operators
- Operator precedence
- Integer Division
- Conversion between types
- User input
- Comments (#)

Exercise

Write a program to prompt the user for hours and rate per hour to compute gross pay.

```
Enter Hours: 35
Enter Rate: 2.75

Pay: 96.25
```

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translators here

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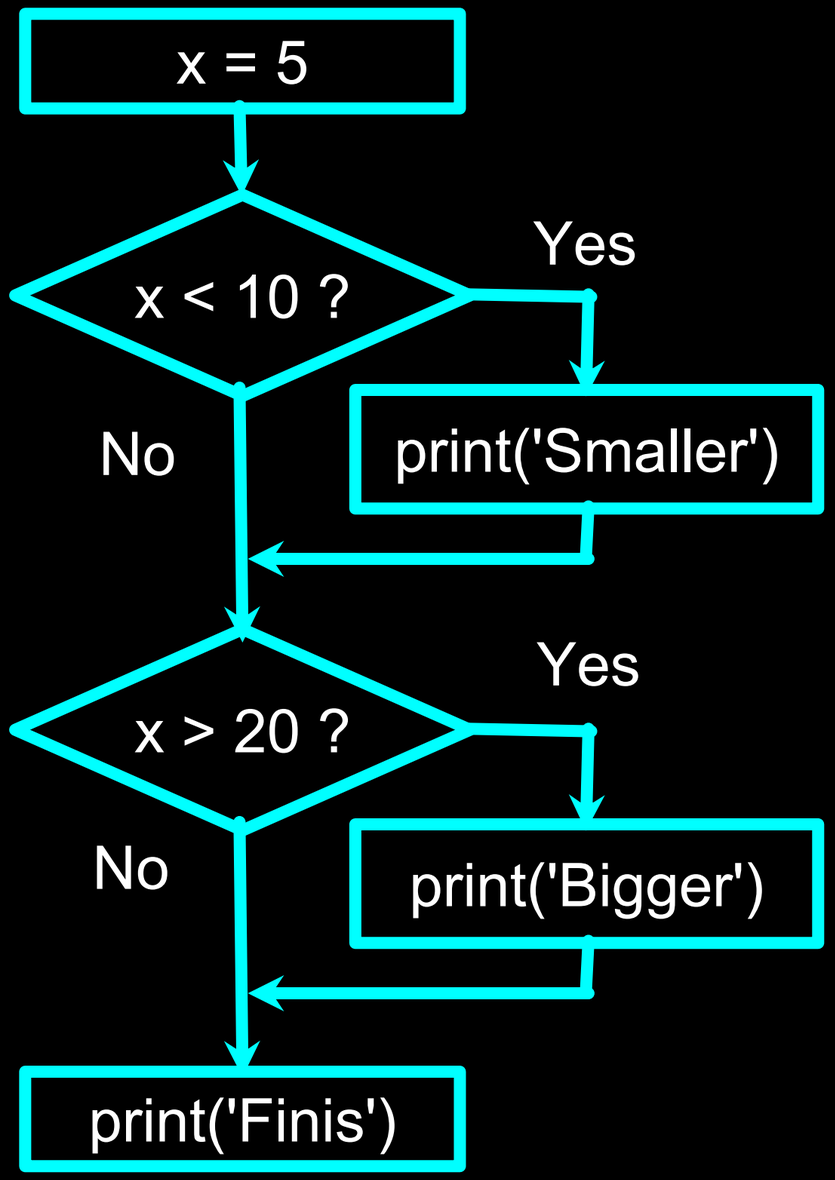
Conditional Execution

Chapter 3

Python for Everybody

www.py4e.com



Conditional Steps

Program:

```
x = 5
if x < 10:
    print('Smaller')
if x > 20:
    print('Bigger')

print('Finis')
```

Output:

```
Smaller
Finis
```

Comparison Operators

- Boolean expressions ask a question and produce a Yes or No result which we use to control program flow
- Boolean expressions using comparison operators evaluate to True / False or Yes / No
- Comparison operators look at variables but do not change the variables

Python	Meaning
<	Less than
<=	Less than or Equal to
==	Equal to
>=	Greater than or Equal to
>	Greater than
!=	Not equal

Remember: "=" is used for assignment.

http://en.wikipedia.org/wiki/George_Boole

Comparison Operators

```
x = 5
if x == 5 :
    print('Equals 5')
if x > 4 :
   print('Greater than 4')
if  x >= 5 :
    print('Greater than or Equals 5')
if x < 6 : print('Less than 6')
if x <= 5 :
    print('Less than or Equals 5')
if x != 6 :
    print('Not equal 6')
```

Equals 5

Greater than 4

Greater than or Equals 5

Less than 6

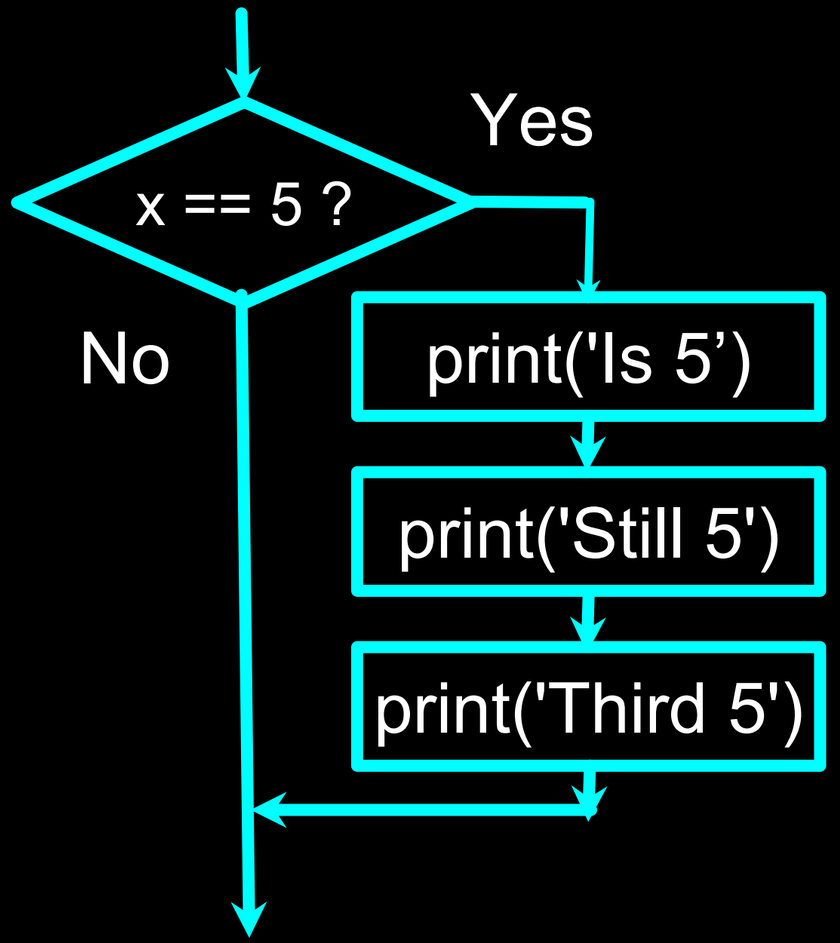
Less than or Equals 5

Not equal 6

One-Way Decisions

```
x = 5
print('Before 5')
if  x == 5 :
    print('Is 5')
    print('Is Still 5')
    print('Third 5')
print('Afterwards 5')
print('Before 6')
if x == 6 :
    print('Is 6')
    print('Is Still 6')
    print('Third 6')
print('Afterwards 6')
```

```
Before 5

Is 5
Is Still 5
Third 5
Afterwards 5
Before 6

Afterwards 6
```

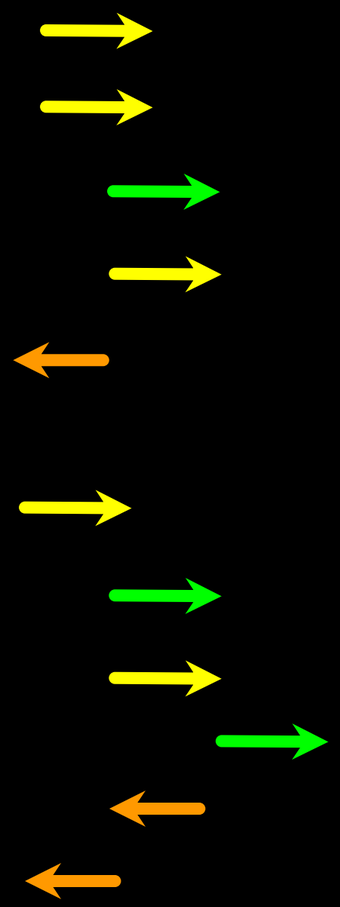


Indentation

- Increase indent indent after an if statement or for statement (after :)
- Maintain indent to indicate the scope of the block (which lines are affected by the if/for)
- Reduce indent back to the level of the if statement or for statement to indicate the end of the block
- Blank lines are ignored - they do not affect indentation
- Comments on a line by themselves are ignored with regard to indentation

increase / maintain after if or for

decrease to indicate end of block



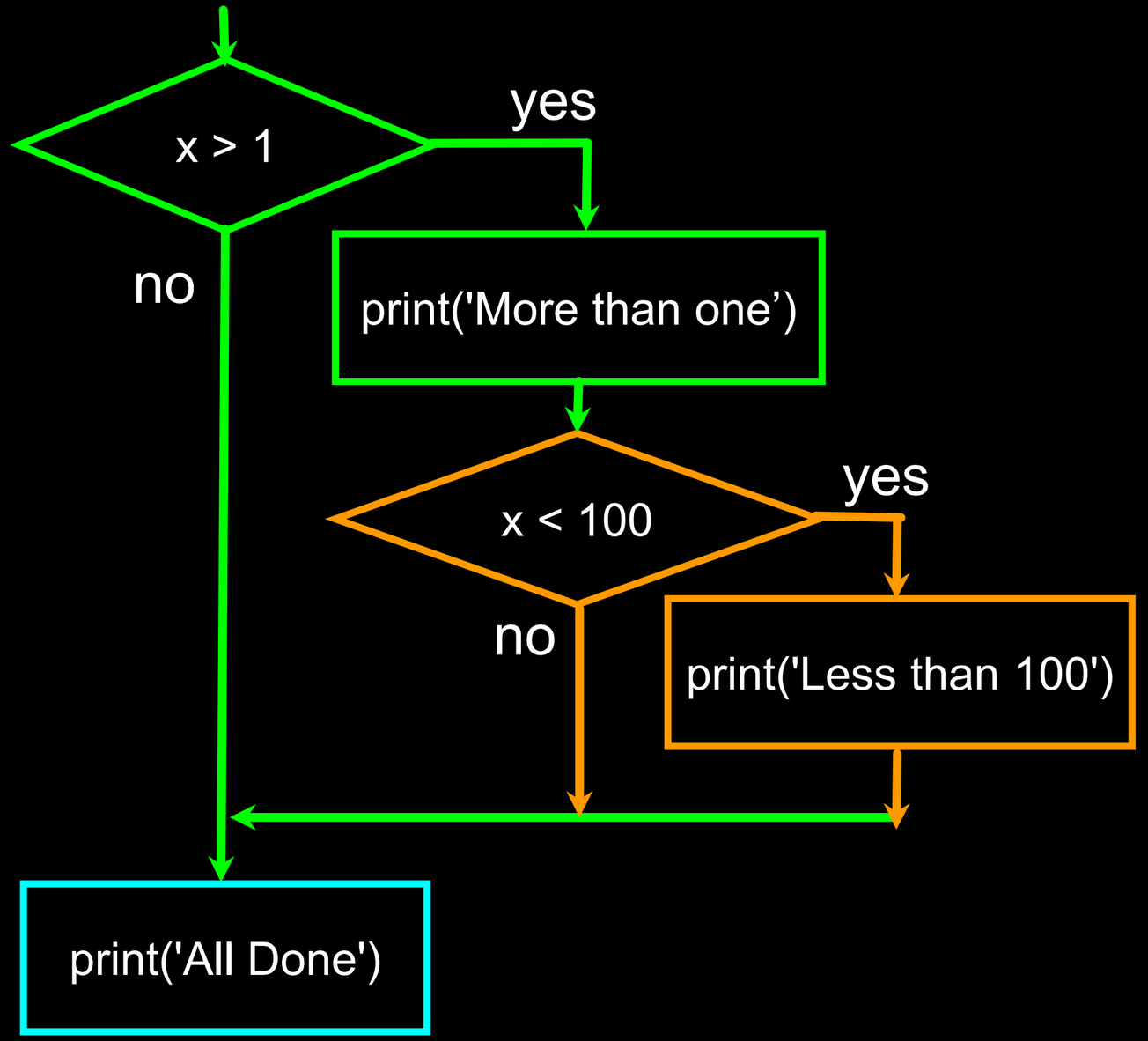
```
x = 5
if x > 2 :
    print('Bigger than 2')
    print('Still bigger')
print('Done with 2')

for i in range(5) :
    print(i)
    if i > 2 :
        print('Bigger than 2')
    print('Done with i', i)
print('All Done')
```

Think About begin/end Blocks

```
x = 5
if x > 2 :
    print('Bigger than 2')
    print('Still bigger')
print('Done with 2')

for i in range(5) :
    print(i)
    if i > 2 :
        print('Bigger than 2')
    print('Done with i', i)
print('All Done')
```

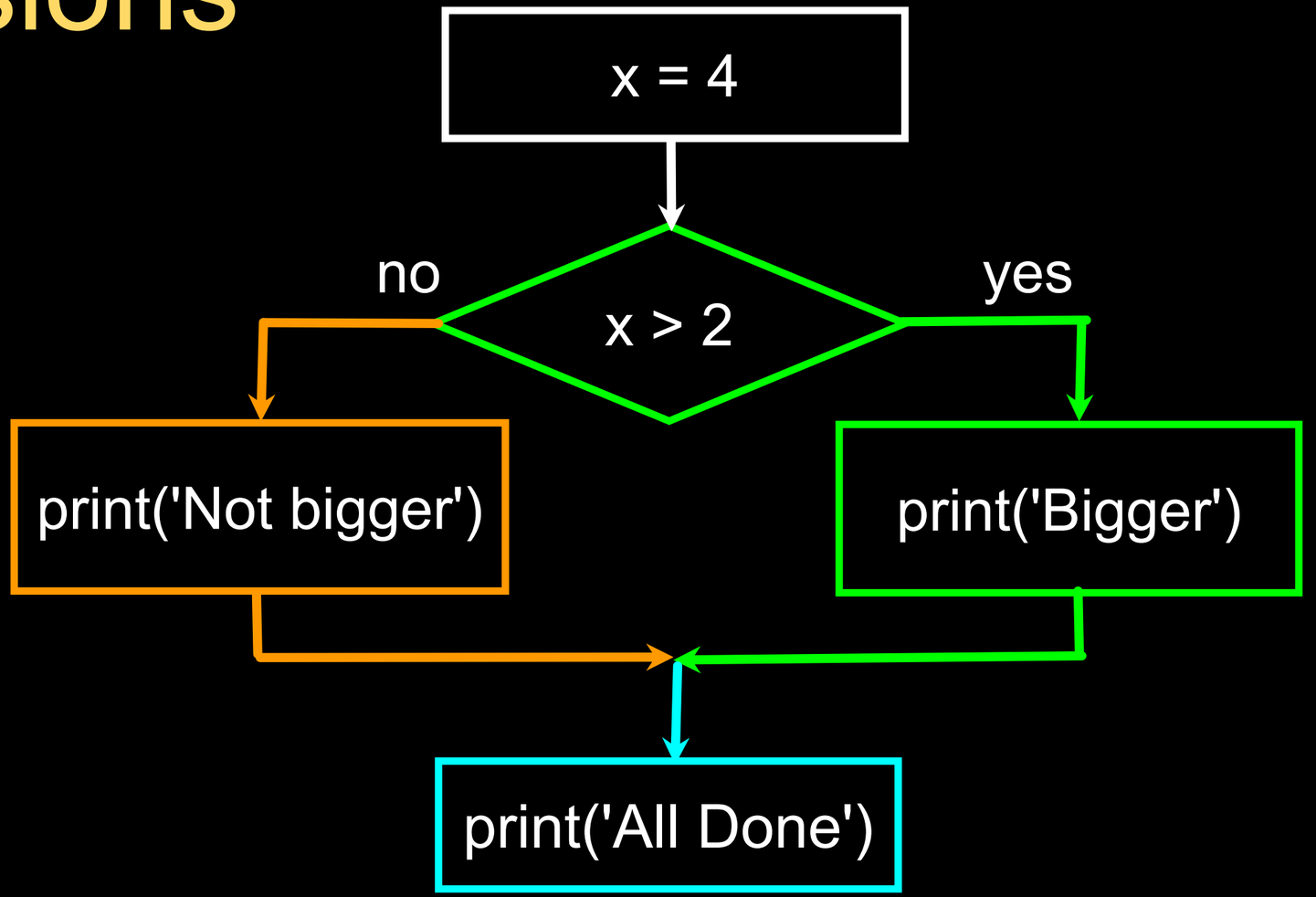
Nested Decisions

```
x = 42
if x > 1 :
    print('More than one')
    if x < 100 :
        print('Less than 100')
print('All done')
```



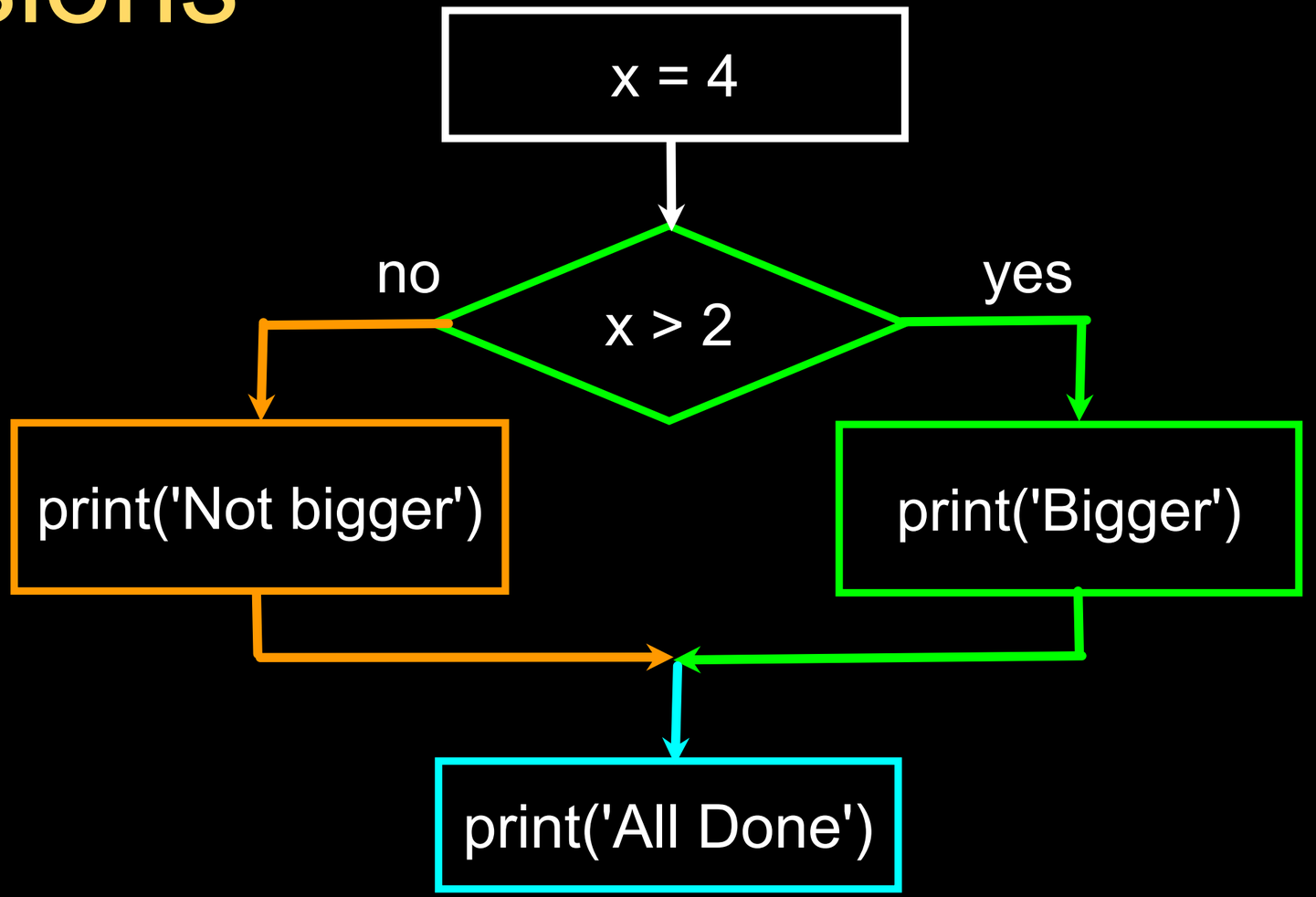
Two-way Decisions

- Sometimes we want to do one thing if a logical expression is true and something else if the expression is false
- It is like a fork in the road - we must choose one or the other path but not both



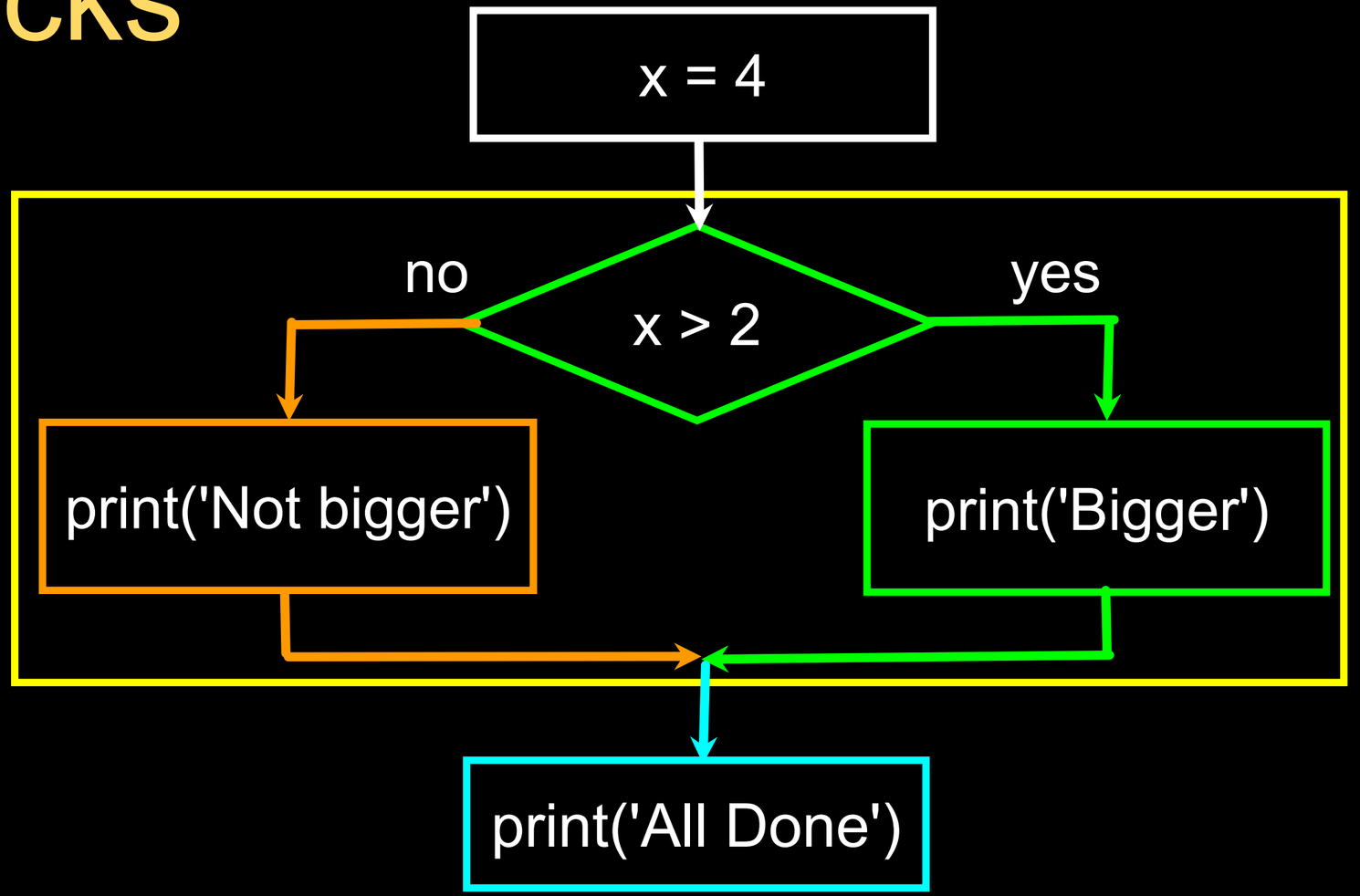
Two-way Decisions with else:

```
x = 4

if x > 2 :
    print('Bigger')
else :
    print('Smaller')

print('All done')
```



Visualize Blocks

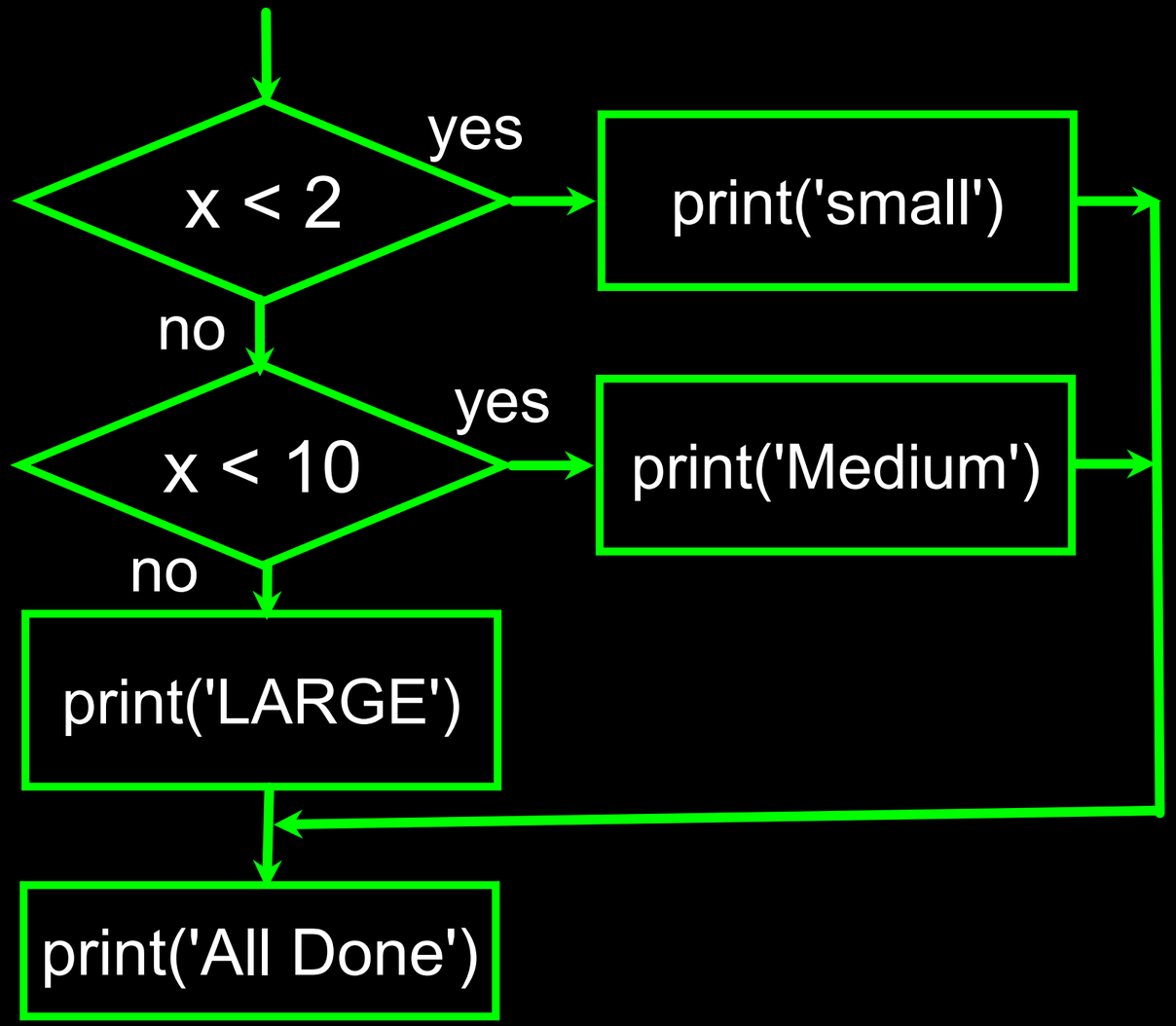
```
x = 4

if x > 2 :
    print('Bigger')
else :
    print('Smaller')

print('All done')
```



More Conditional Structures…

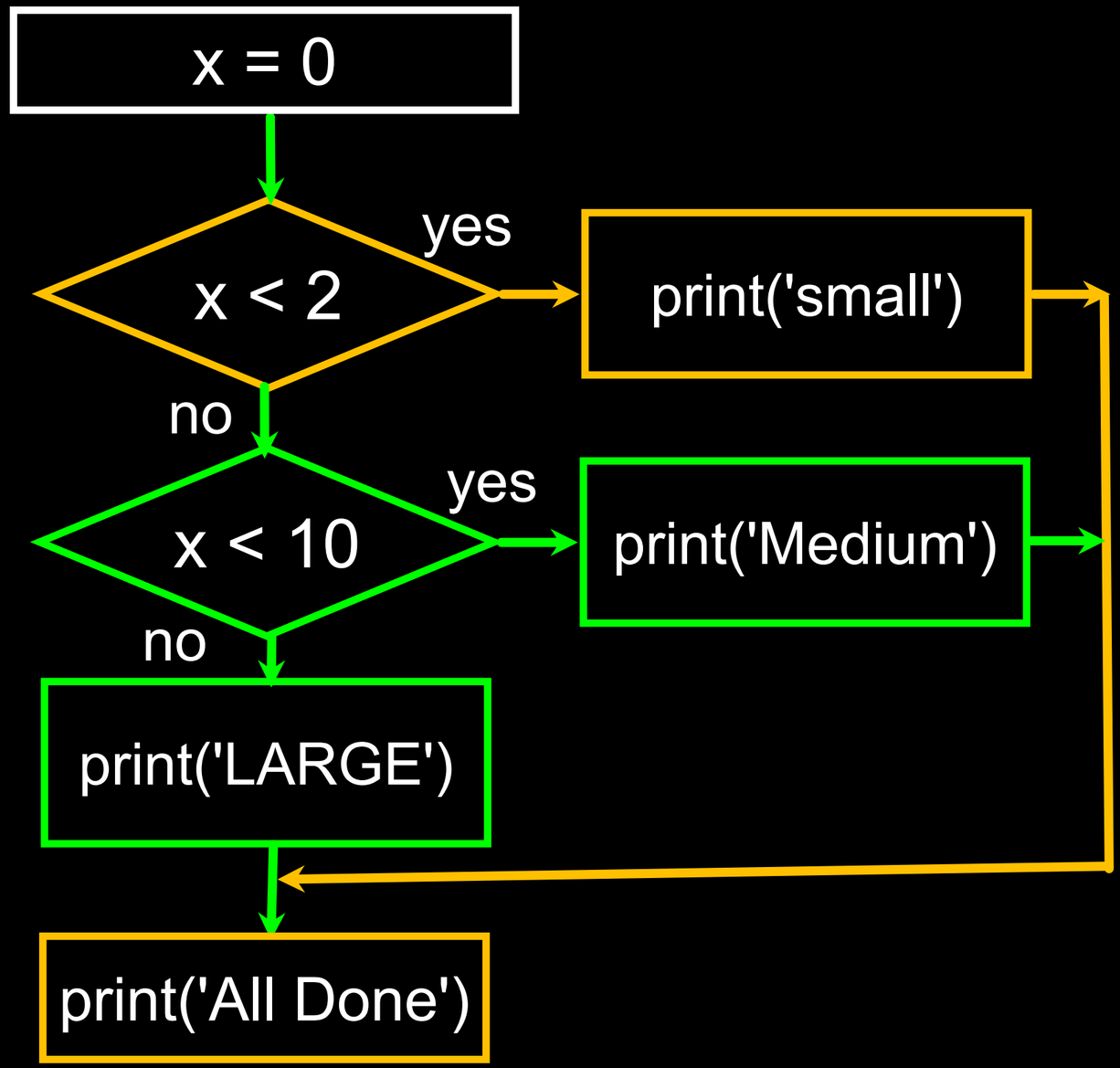
Multi-way

```
if x < 2 :
    print('small')
elif x < 10 :
    print('Medium')
else :
    print('LARGE')
print('All done')
```



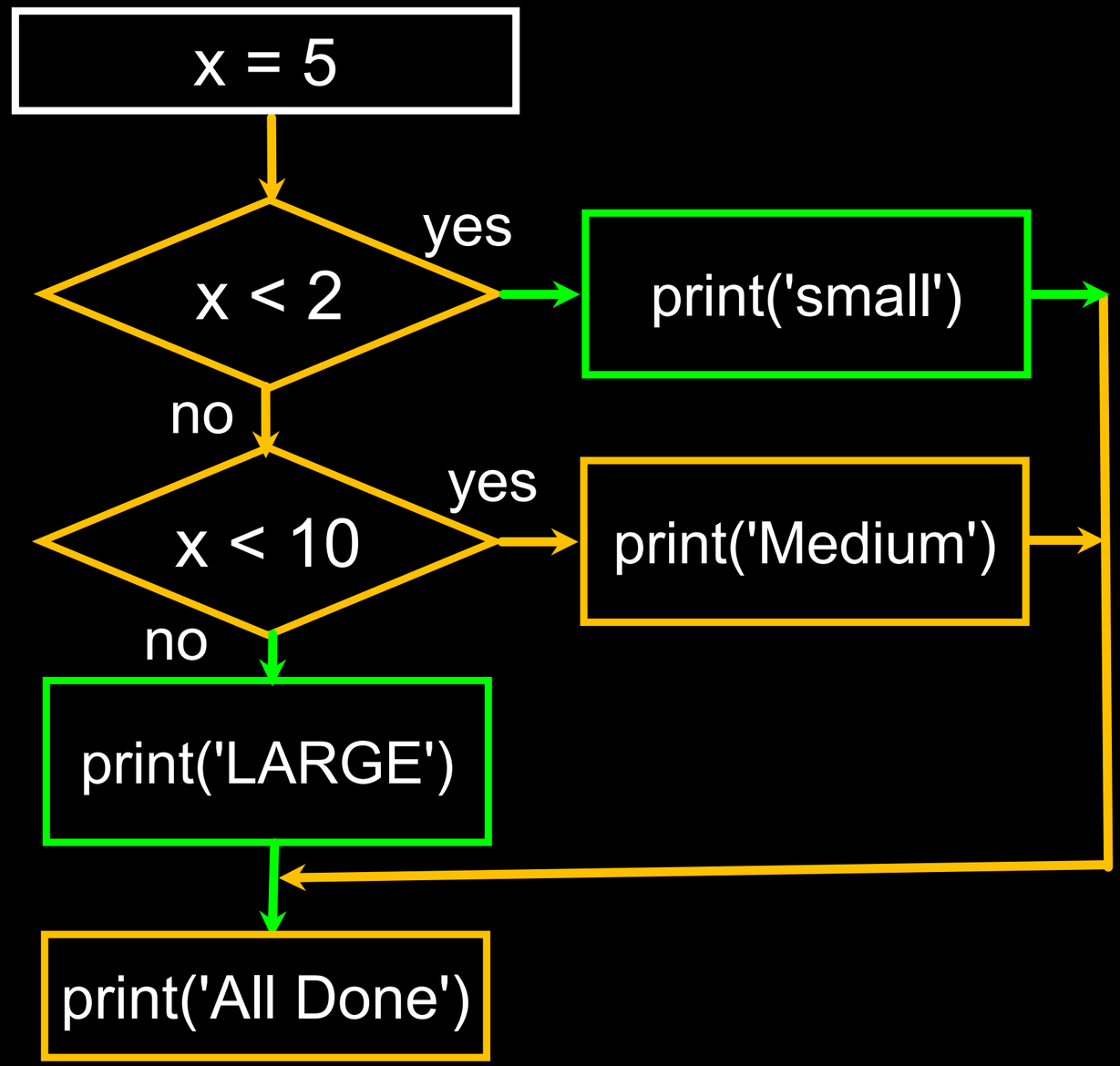
Multi-way

```
x = 0
if x < 2 :
    print('small')
elif x < 10 :
    print('Medium')
else :
    print('LARGE')
print('All done')
```



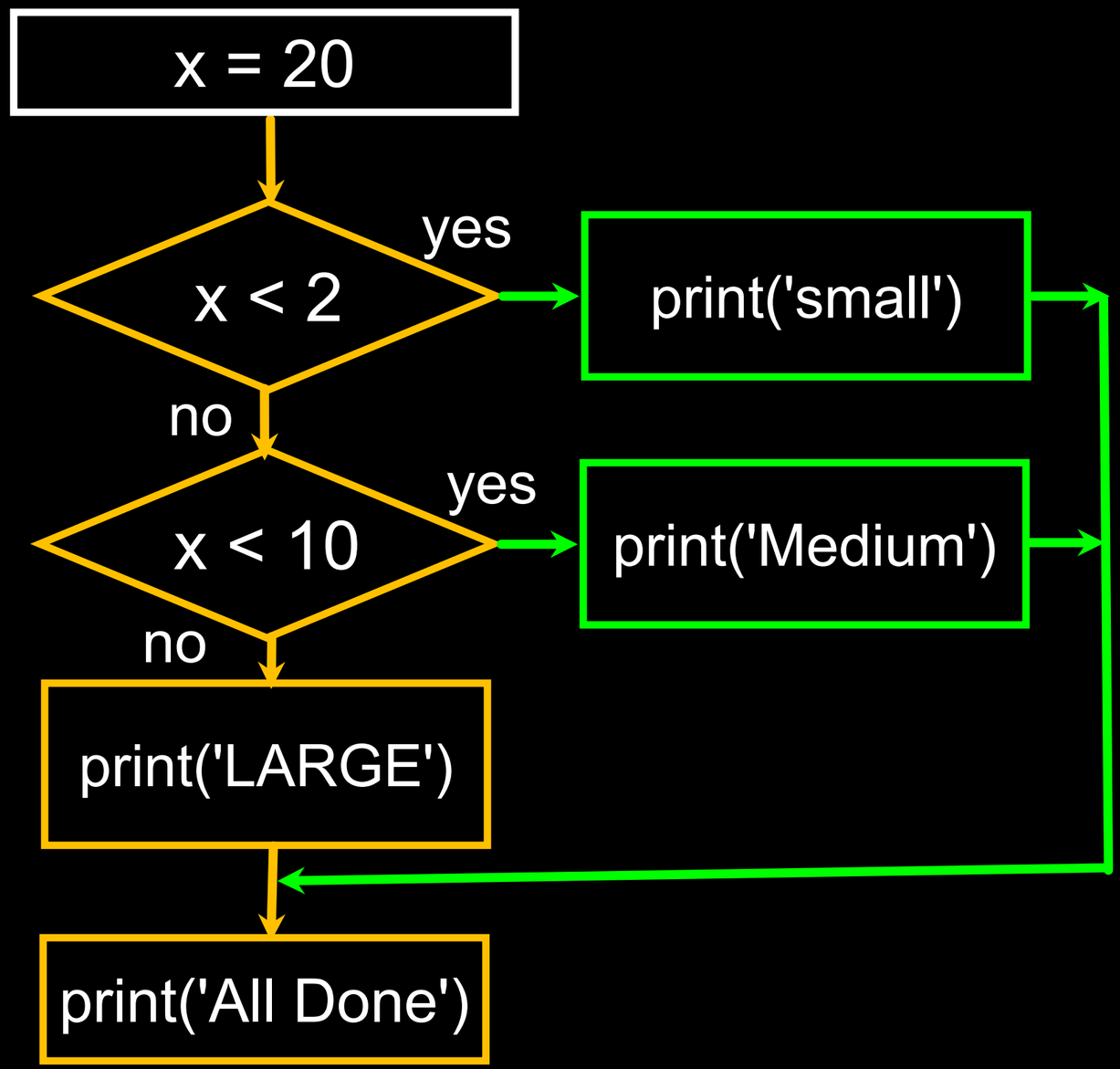
Multi-way

```
x = 5
if x < 2 :
    print('small')
elif x < 10 :
    print('Medium')
else :
    print('LARGE')
print('All done')
```



Multi-way

```
x = 20
if x < 2 :
    print('small')
elif x < 10 :
    print('Medium')
else :
    print('LARGE')
print('All done')
```



Multi-way

```
# No Else
x = 5
if x < 2 :
    print('Small')
elif x < 10 :
    print('Medium')

print('All done')
```

```
if x < 2 :
    print('Small')
elif x < 10 :
    print('Medium')
elif x < 20 :
    print('Big')
elif x < 40 :
    print('Large')
elif x < 100:
    print('Huge')
else :
    print('Ginormous')
```

Multi-way Puzzles

Which will never print regardless of the value for x?

```
if x < 2 :
    print('Below 2')
elif x >= 2 :
    print('Two or more')
else :
    print('Something else')
```

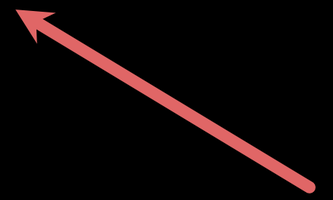
```
if x < 2 :
    print('Below 2')
elif x < 20 :
    print('Below 20')
elif x < 10 :
    print('Below 10')
else :
    print('Something else')
```

The try / except Structure

- You surround a dangerous section of code with try and except
- If the code in the try works - the except is skipped
- If the code in the try fails - it jumps to the except section

```
$ cat notry.py
astr = 'Hello Bob'
istr = int(astr)
print('First', istr)
astr = '123'
istr = int(astr)
print('Second', istr)
```

```
$ python3 notry.py
Traceback (most recent call last):
File "notry.py", line 2, in <module>
istr = int(astr)ValueError: invalid literal
for int() with base 10: 'Hello Bob'
```



All
Done

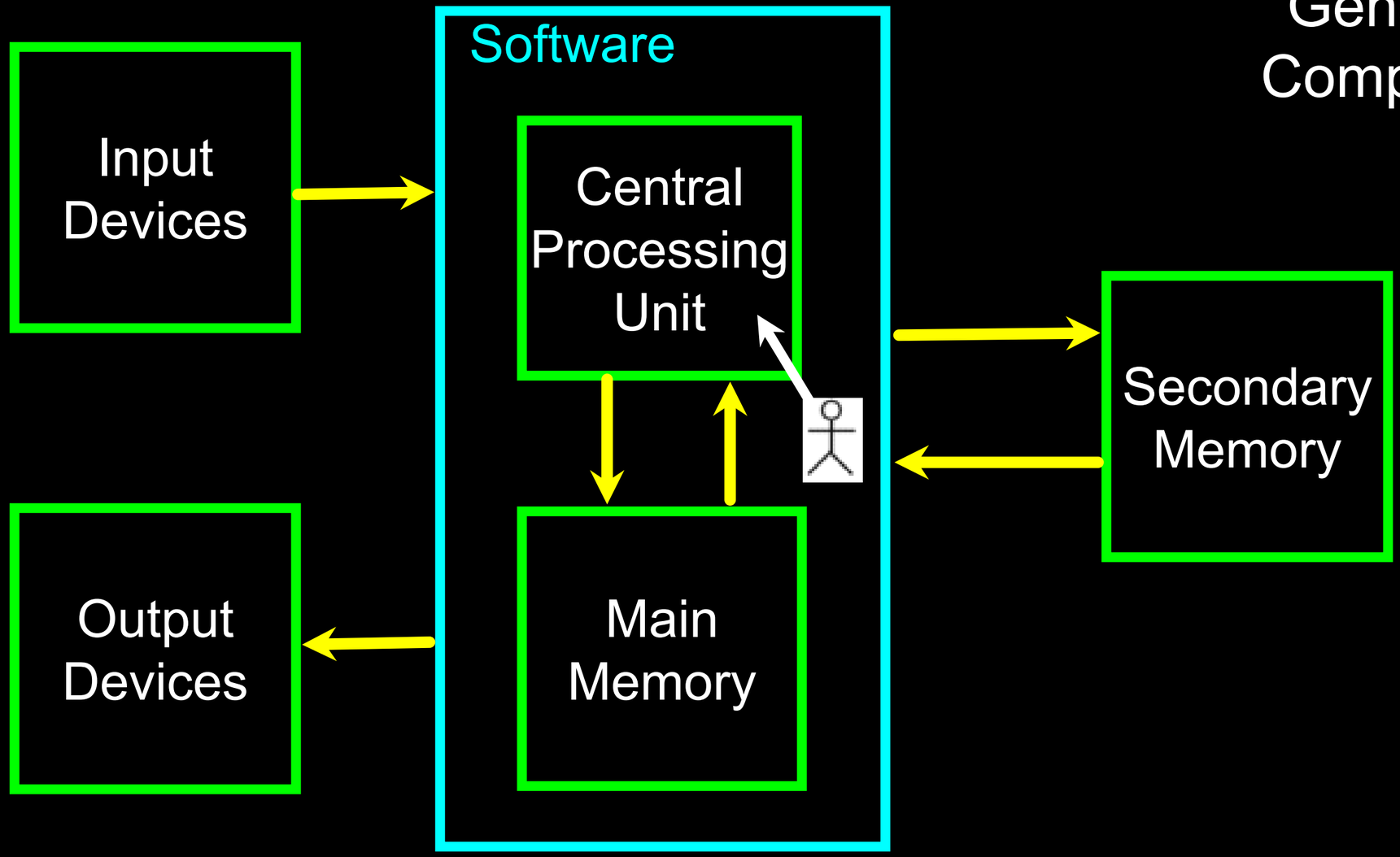
The program stops here

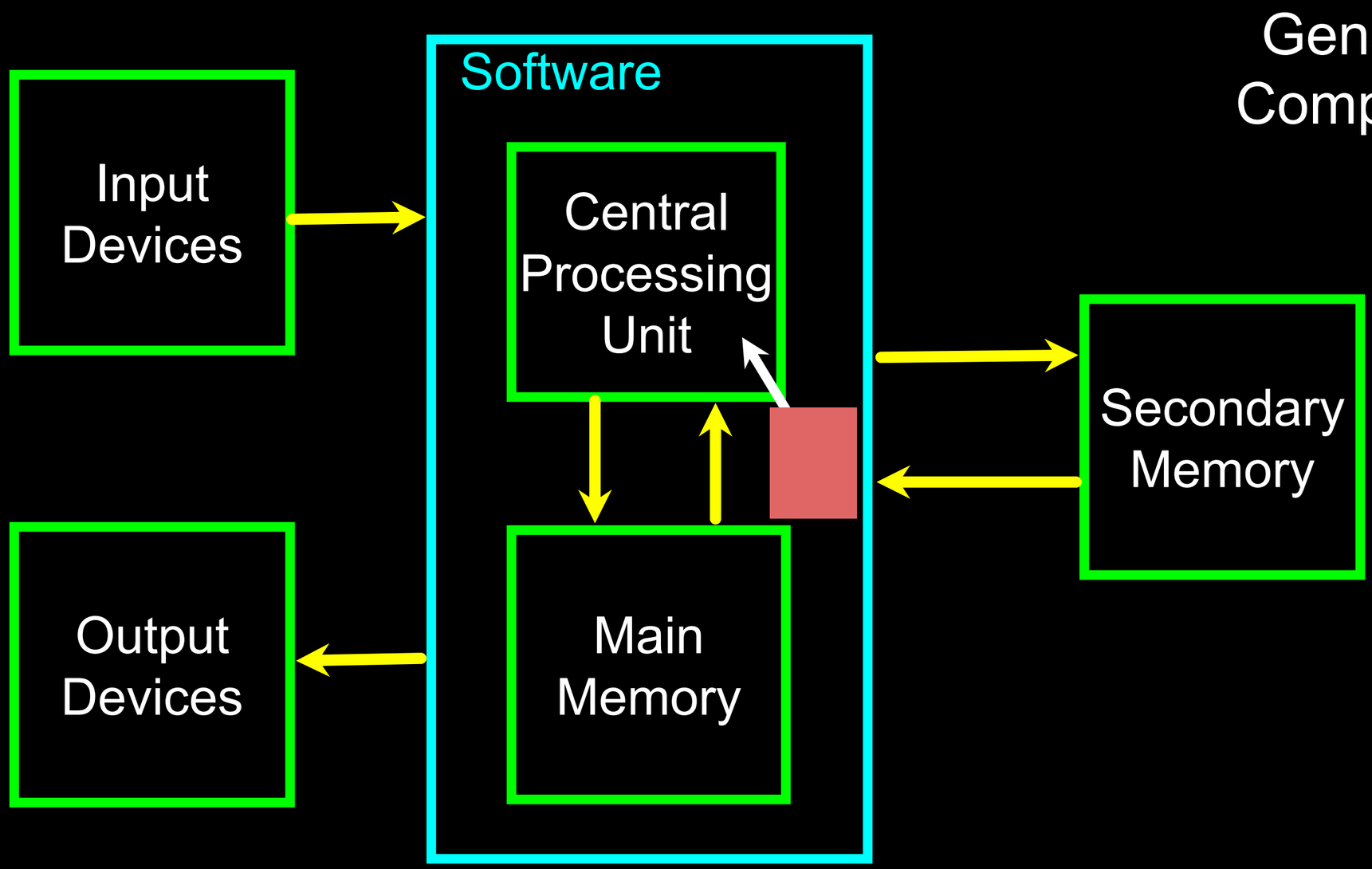
```
$ cat notry.py
astr = 'Hello Bob'
istr = int(astr)
```

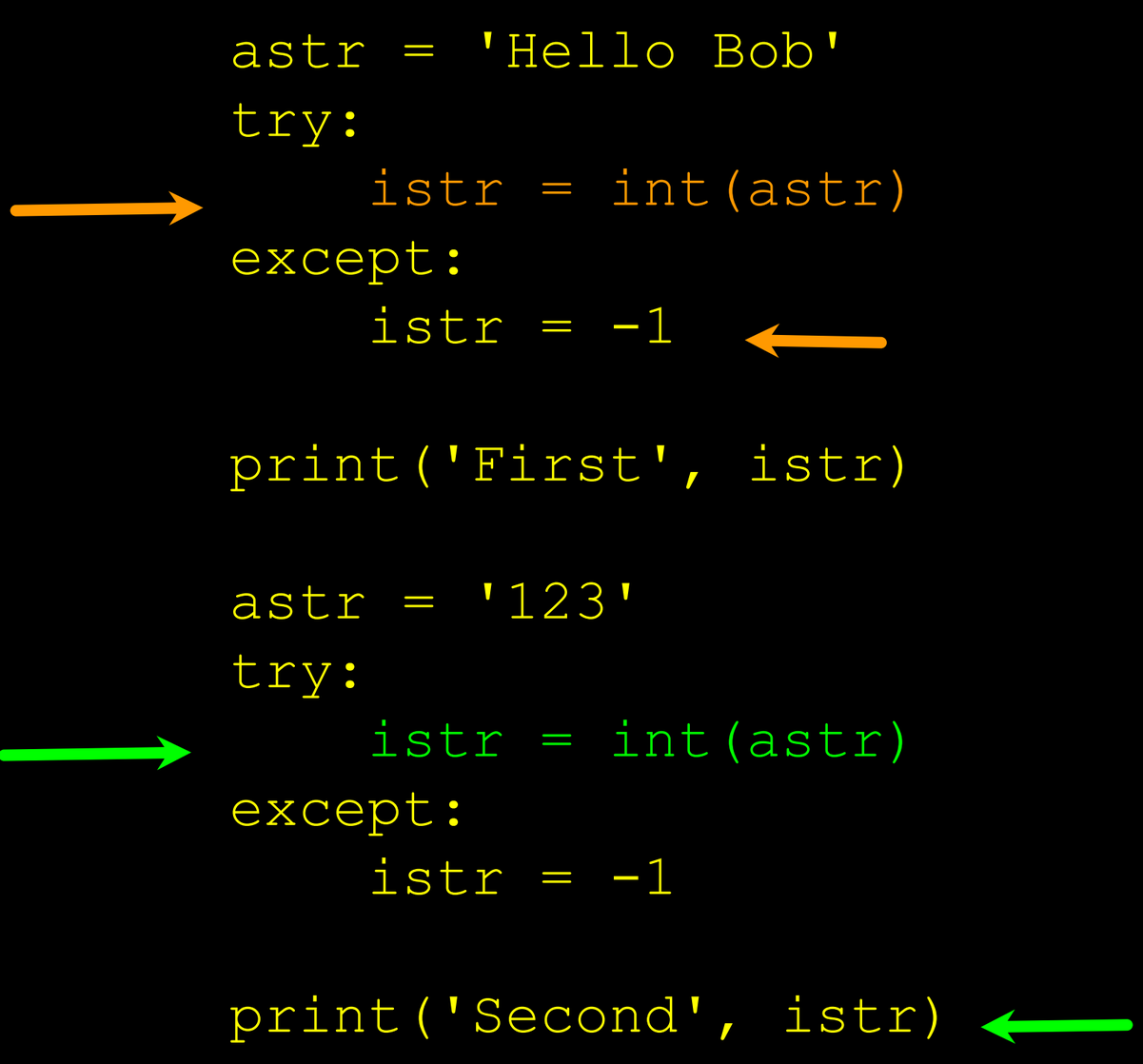
```
$ python3 notry.py
Traceback (most recent call last):
File "notry.py", line 2, in <module>
istr = int(astr)ValueError: invalid literal
for int() with base 10: 'Hello Bob'
```

All Done

Generic Computer




Generic
Computer
Software
Input
Devices
Central
Processing
Unit
Secondary
Memory
Output
Devices
Main
Memory



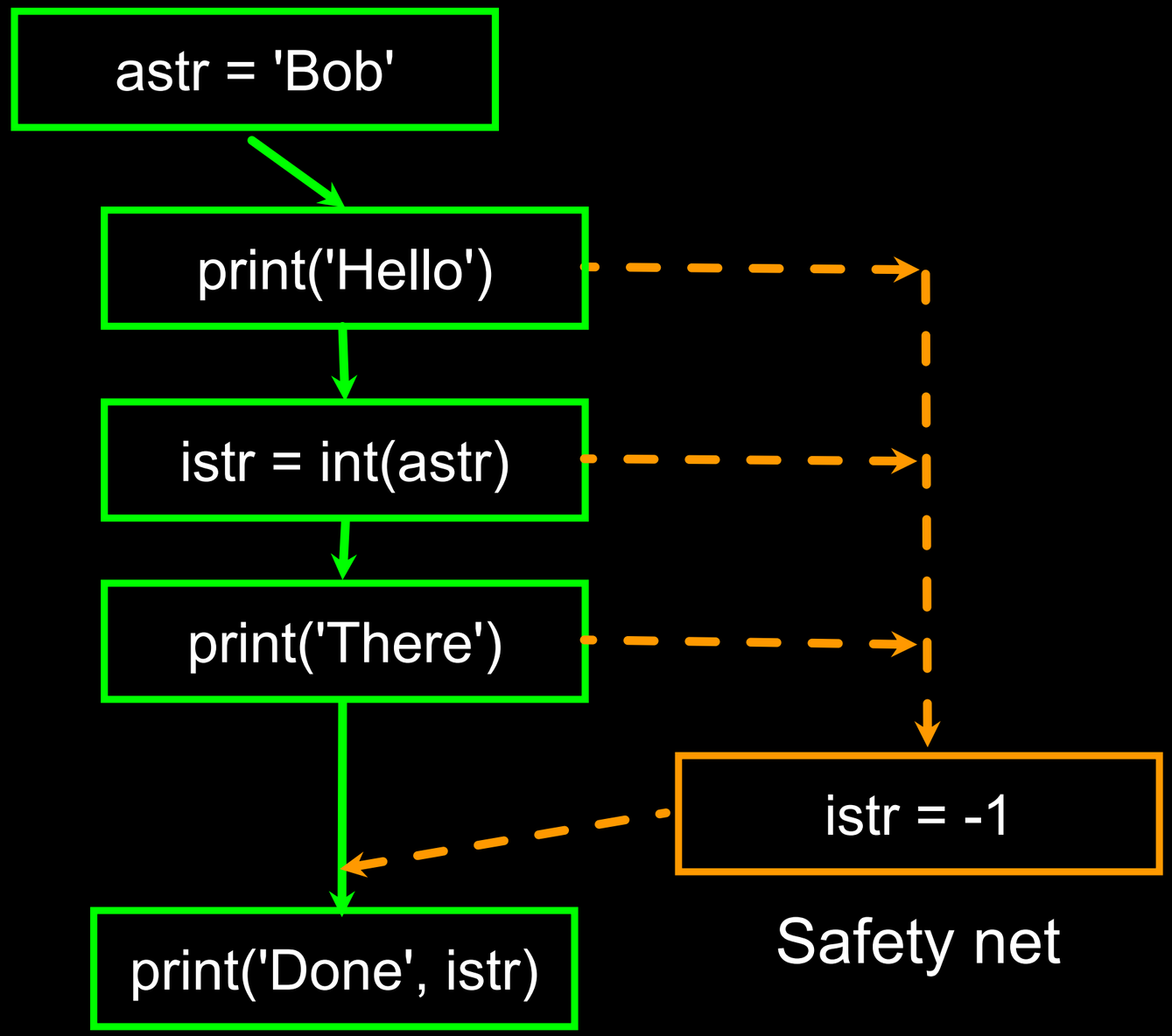
When the first conversion fails - it just drops into the except: clause and the program continues.

```
$ python tryexcept.py
First -1
Second 123
```

When the second conversion succeeds - it just skips the except: clause and the program continues.

try / except

```
astr = 'Bob'
try:
    print('Hello')
    istr = int(astr)
    print('There')
except:
    istr = -1

print('Done', istr)
```



Sample try / except

```
rawstr = input('Enter a number:')
try:
    ival = int(rawstr)
except:
    ival = -1

if ival > 0 :
    print('Nice work')
else:
    print('Not a number')
```

```
$ python3 trynum.py
Enter a number:42
Nice work
$ python3 trynum.py
Enter a number:forty-two
Not a number
$
```

Summary

- Comparison operators
  == <= >= > < !=
- Indentation
- One-way Decisions
- Two-way decisions:
  if: and else:
- Nested Decisions
- Multi-way decisions using elif
- try / except to compensate for errors

Exercise

Rewrite your pay computation to give the employee 1.5 times the hourly rate for hours worked above 40 hours.

```
Enter Hours: 45
Enter Rate: 10

Pay: 475.0
```

475 = 40 * 10 + 5 * 15

Exercise

Rewrite your pay program using try and except so that your program handles non-numeric input gracefully.

```
Enter Hours: 20
Enter Rate: nine
Error, please enter numeric input

Enter Hours: forty
Error, please enter numeric input
```

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

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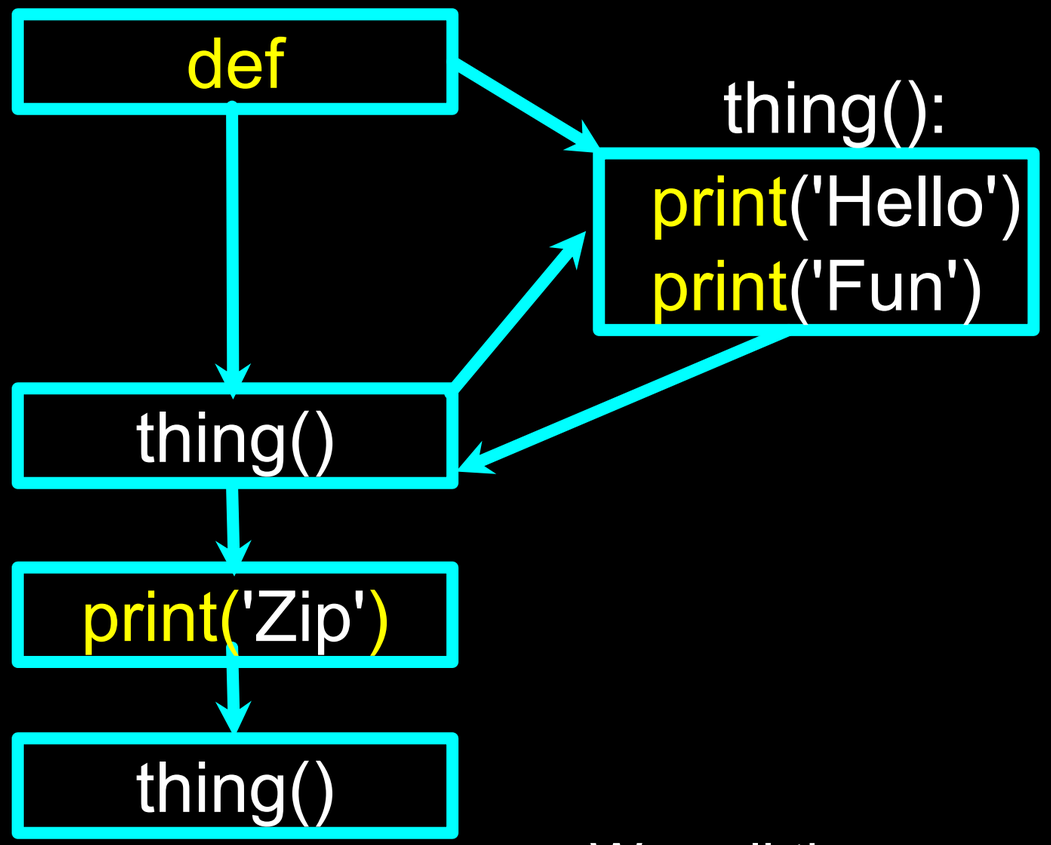
Functions

Chapter 4

Python for Everybody

www.py4e.com

Stored (and reused) Steps



Program:

```
def thing():
    print('Hello')
    print('Fun')

thing()
print('Zip')
thing()
```

Output:

```
Hello
Fun
Zip
Hello
Fun
```

We call these reusable pieces of code “functions”

Python Functions

- There are two kinds of functions in Python.

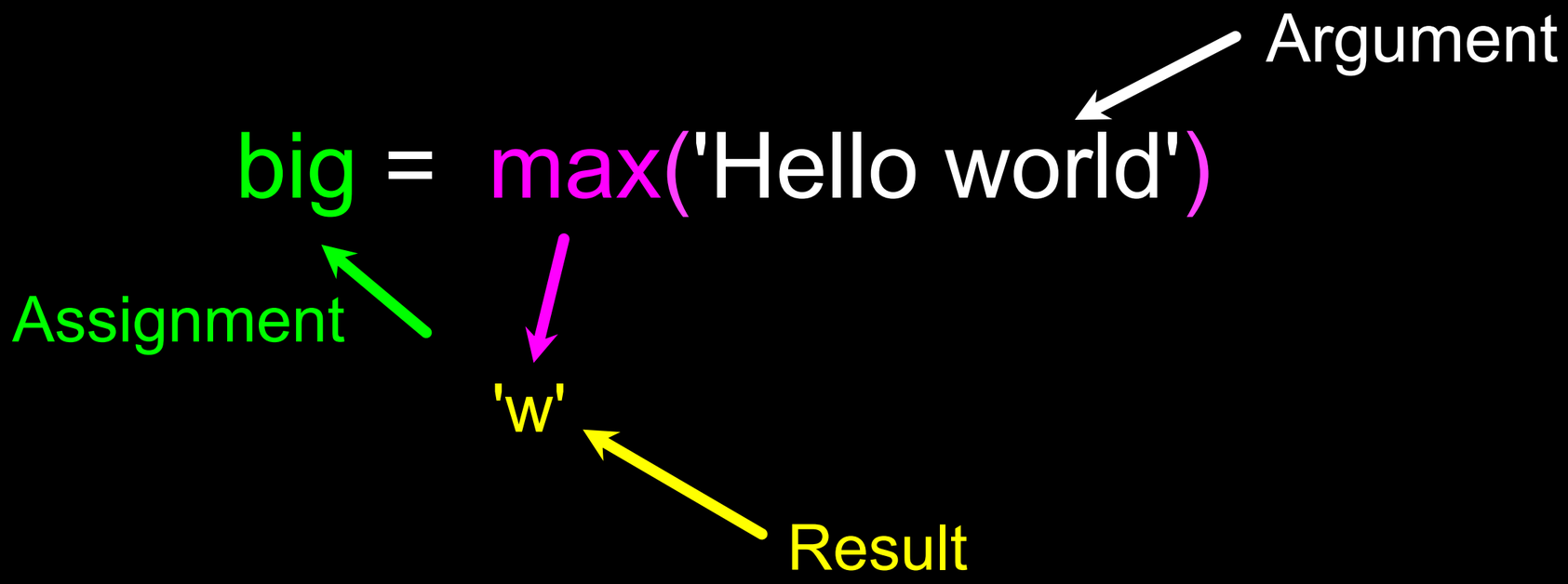
  - Built-in functions that are provided as part of Python - print(), input(), type(), float(), int() ...

  - Functions that we define ourselves and then use

- We treat function names as “new” reserved words (i.e., we avoid them as variable names)

Function Definition

- In Python a function is some reusable code that takes arguments(s) as input, does some computation, and then returns a result or results
- We define a function using the def reserved word
- We call/invoke the function by using the function name, parentheses, and arguments in an expression



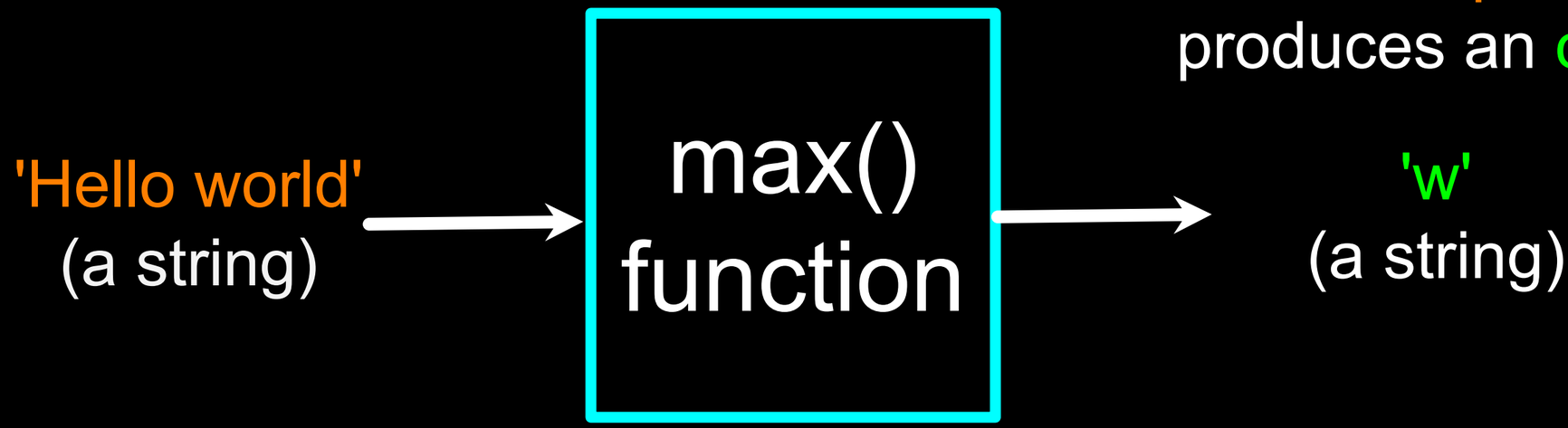

```
>>> big = max('Hello world')
>>> print(big)
w
>>> tiny = min('Hello world')
>>> print(tiny)

>>>
```

Max Function

```
>>> big = max('Hello world')
>>> print(big)
w
```

A function is some stored code that we use. A function takes some input and produces an output.

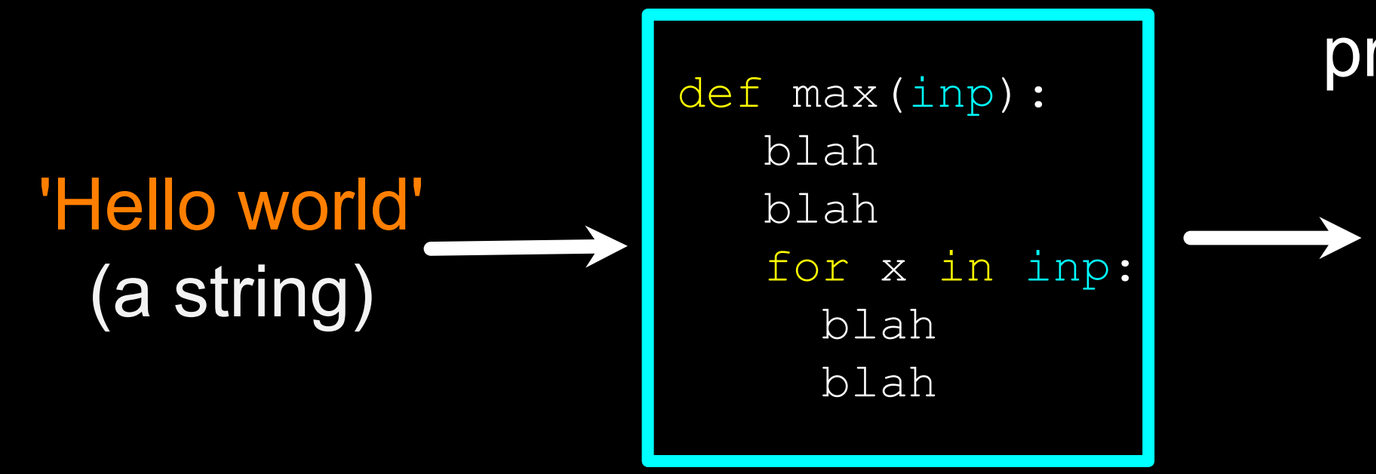


Guido wrote this code

Max Function

```
>>> big = max('Hello world')
>>> print(big)
w
```

A function is some stored code that we use. A function takes some input and produces an output.



Guido wrote this code

Type Conversions

- When you put an integer and floating point in an expression, the integer is implicitly converted to a float
- You can control this with the built-in functions int() and float()

```
>>> print(float(99) / 100)
0.99
>>> i = 42
>>> type(i)
<class 'int'>
>>> f = float(i)
>>> print(f)
42.0
>>> type(f)
<class 'float'>
>>> print(1 + 2 * float(3) / 4 - 5)
-2.5
>>>
```

String Conversions

- You can also use int() and float() to convert between strings and integers
- You will get an error if the string does not contain numeric characters

```
>>> sval = '123'
>>> type(sval)
<class 'str'>
>>> print(sval + 1)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: can only concatenate str
(not "int") to str
>>> ival = int(sval)
>>> type(ival)
<class 'int'>
>>> print(ival + 1)
124
>>> nsv = 'hello bob'
>>> niv = int(nsv)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: invalid literal for int()
```

Functions of Our Own…

Building our Own Functions

- We create a new function using the def keyword followed by optional parameters in parentheses
- We indent the body of the function
- This defines the function but does not execute the body of the function

```
def print_lyrics():
    print("I'm a lumberjack, and I'm okay.")
    print('I sleep all night and I work all day.')
```

print_lyrics():

```
print("I'm a lumberjack, and I'm okay.")
print('I sleep all night and I work all day.')
```

```
x = 5
print('Hello')

def print_lyrics():
    print("I'm a lumberjack, and I'm okay.")
    print('I sleep all night and I work all day.')

print('Yo')
x = x + 2
print(x)
```

```
Hello
Yo
7
```

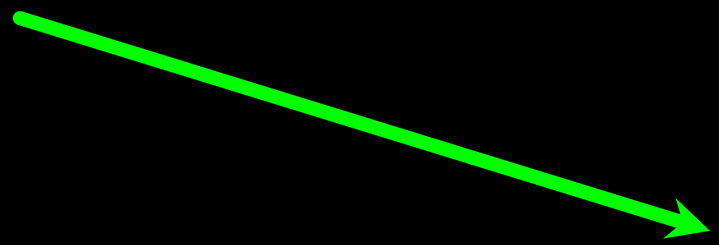
Definitions and Uses

- Once we have defined a function, we can call (or invoke) it as many times as we like
- This is the store and reuse pattern

```
x = 5
print('Hello')

def print_lyrics():
    print("I'm a lumberjack, and I'm okay.")
    print('I sleep all night and I work all day.')

print('Yo')
print_lyrics()
x = x + 2
print(x)
```



```
Hello
Yo
I'm a lumberjack, and I'm okay.
I sleep all night and I work all day.
7
```

Arguments

- An argument is a value we pass into the function as its input when we call the function
- We use arguments so we can direct the function to do different kinds of work when we call it at different times
- We put the arguments in parentheses after the name of the function

```
big = max('Hello world')
```

Argument

Parameters

A parameter is a variable which we use in the function definition. It is a “handle” that allows the code in the function to access the arguments for a particular function invocation.

Return Values

Often a function will take its arguments, do some computation, and return a value to be used as the value of the function call in the calling expression. The return keyword is used for this.

```
def greet():
    return "Hello"

print(greet(), "Glenn")
print(greet(), "Sally")
```

```
Hello Glenn
Hello Sally
```

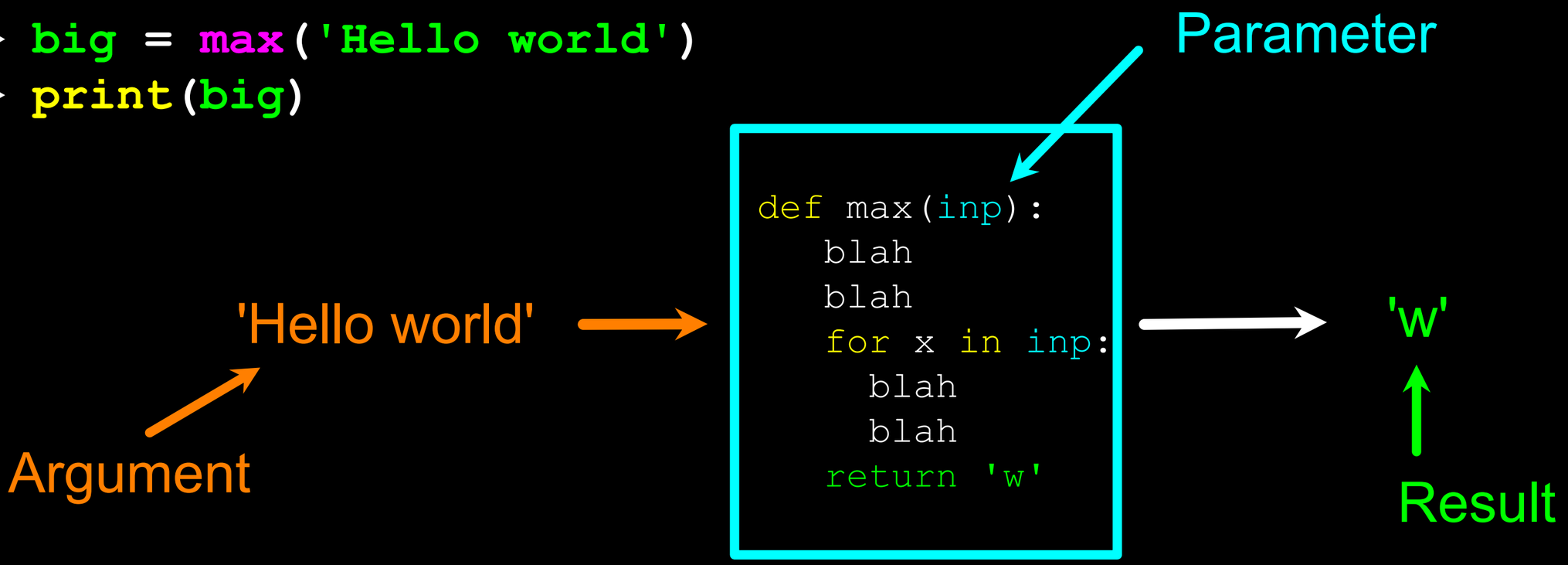
Return Value

- A “fruitful” function is one that produces a result (or return value)
- The return statement ends the function execution and “sends back” the result of the function

```
>>> def greet(lang):
...     if lang == 'es':
...         return 'Hola'
...     elif lang == 'fr':
...         return 'Bonjour'
...     else:
...         return 'Hello'
...
>>> print(greet('en'),'Glenn')
Hello Glenn
>>> print(greet('es'),'Sally')
Hola Sally
>>> print(greet('fr'),'Michael')
Bonjour Michael
>>>
```

Arguments, Parameters, and Results

```
>>> big = max('Hello world')
>>> print(big)
w
```



Multiple Parameters / Arguments

- We can define more than one parameter in the function definition
- We simply add more arguments when we call the function
- We match the number and order of arguments and parameters

```
def addtwo(a, b):
    added = a + b
    return added

x = addtwo(3, 5)
print(x)
```

```
8
```

Void (non-fruitful) Functions

- When a function does not return a value, we call it a “void” function
- Functions that return values are “fruitful” functions
- Void functions are “not fruitful”

To function or not to function...

- Organize your code into “paragraphs” - capture a complete thought and “name it”
- Don’t repeat yourself - make it work once and then reuse it
- If something gets too long or complex, break it up into logical chunks and put those chunks in functions
- Make a library of common stuff that you do over and over - perhaps share this with your friends...

Summary

- Functions
- Built-In Functions
- Type conversion (int, float)
- String conversions
- Parameters
- Arguments
- Results (fruitful functions)
- Void (non-fruitful) functions
- Why use functions?

Exercise

Rewrite your pay computation with time-and-a-half for overtime and create a function called computepay which takes two parameters (hours and rate).

Enter Hours: 45
Enter Rate: 10

Pay: 475.0

475 = 40 * 10 + 5 * 15

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

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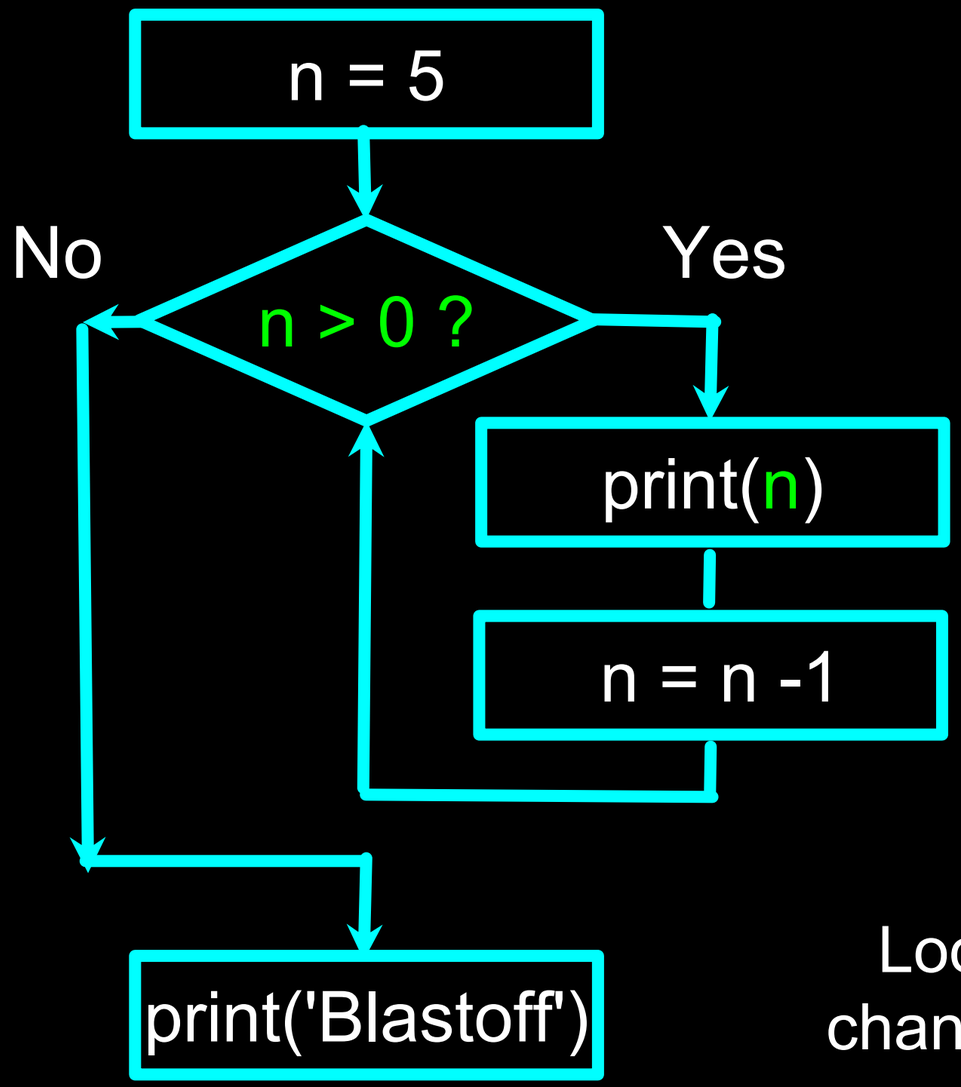
Loops and Iteration

Chapter 5

Python for Everybody

www.py4e.com

Repeated Steps



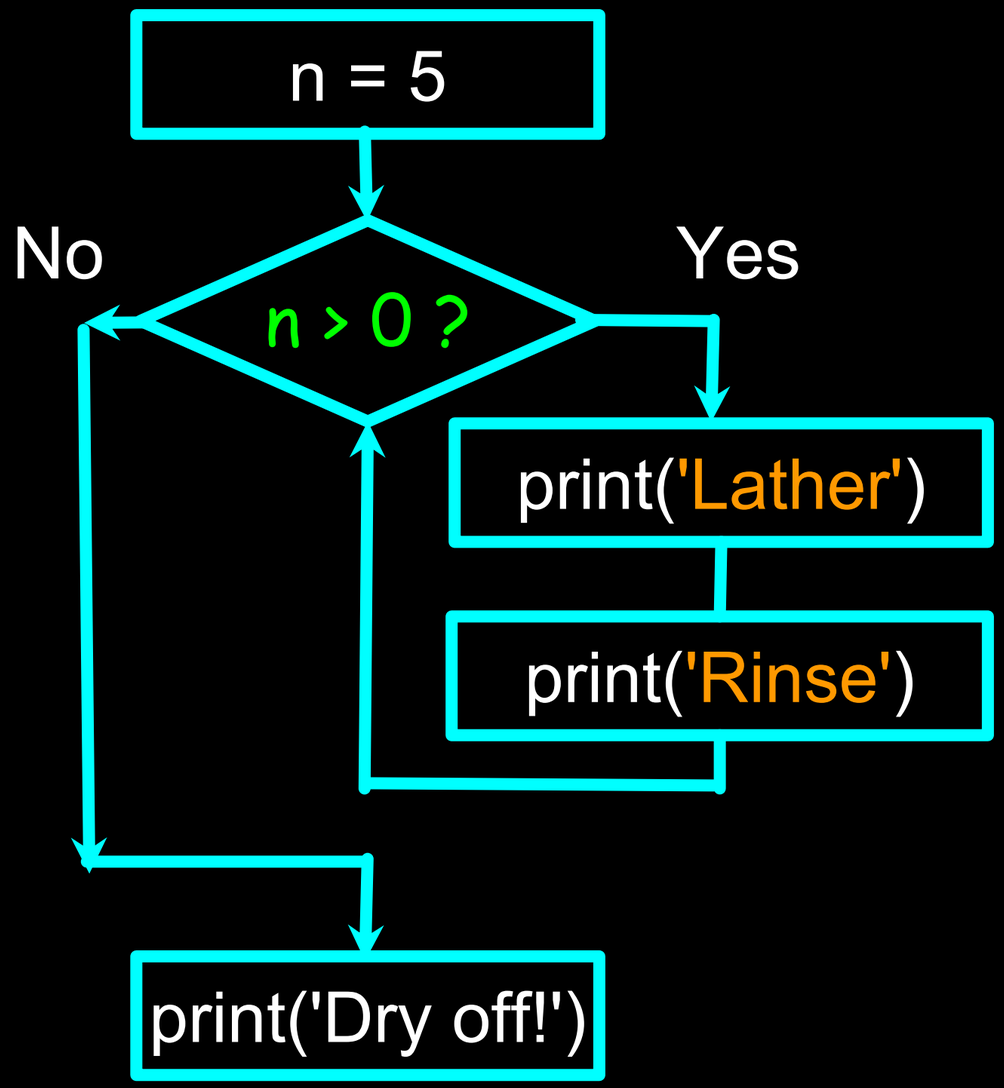
Program:

```
n = 5
while n > 0 :
    print(n)
    n = n - 1
print('Blastoff!')
print(n)
```

Output:

```
5
4
3
2
1
Blastoff!
0
```

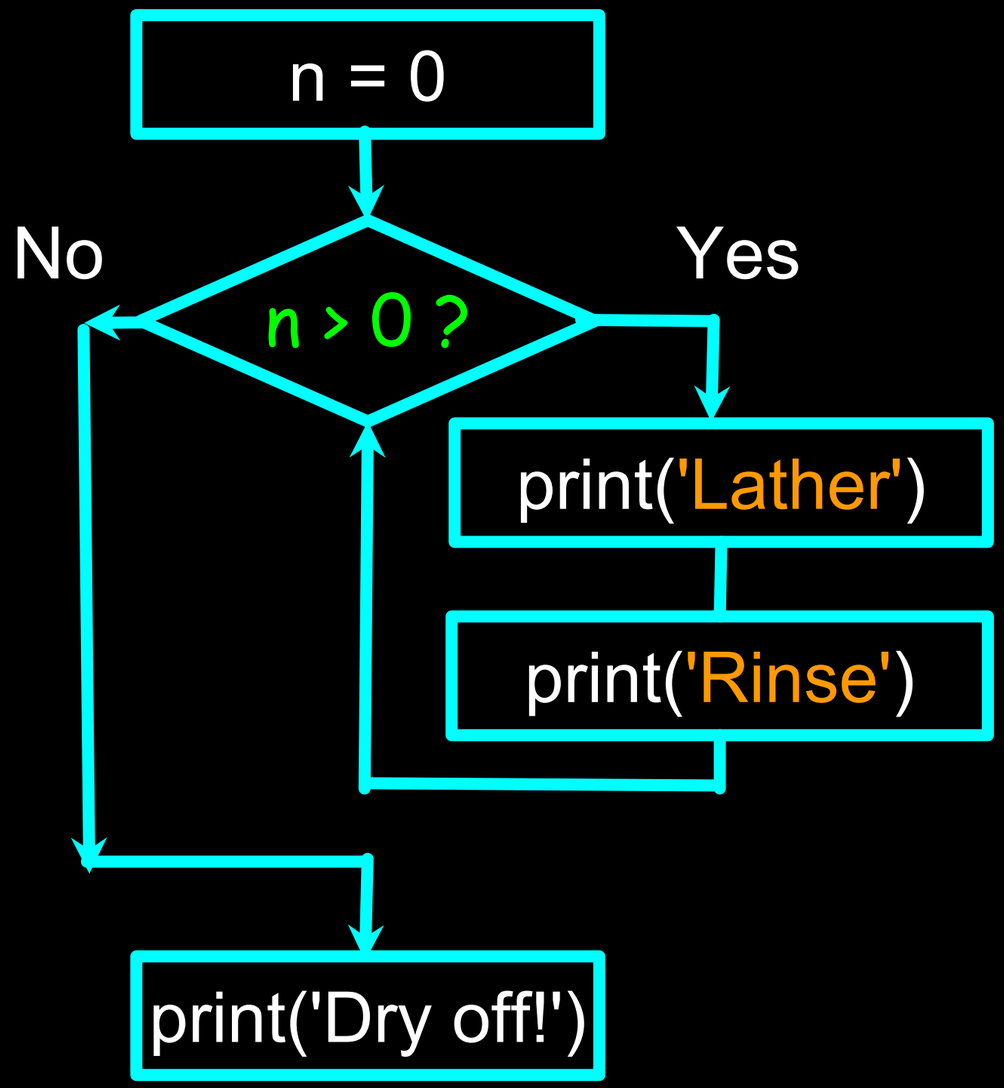
Loops (repeated steps) have iteration variables that change each time through a loop. Often these iteration variables go through a sequence of numbers.



An Infinite Loop

```
n = 5
while n > 0 :
    print('Lather')
    print('Rinse')
print('Dry off!')
```

What is wrong with this loop?



Another Loop

```
n = 0
while n > 0 :
    print('Lather')
    print('Rinse')
print('Dry off!')
```

What is this loop doing?

Breaking Out of a Loop

- The break statement ends the current loop and jumps to the statement immediately following the loop
- It is like a loop test that can happen anywhere in the body of the loop

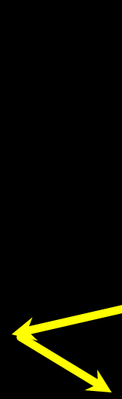
```
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> finished
finished
> done
Done!
```

Breaking Out of a Loop

- The break statement ends the current loop and jumps to the statement immediately following the loop
- It is like a loop test that can happen anywhere in the body of the loop

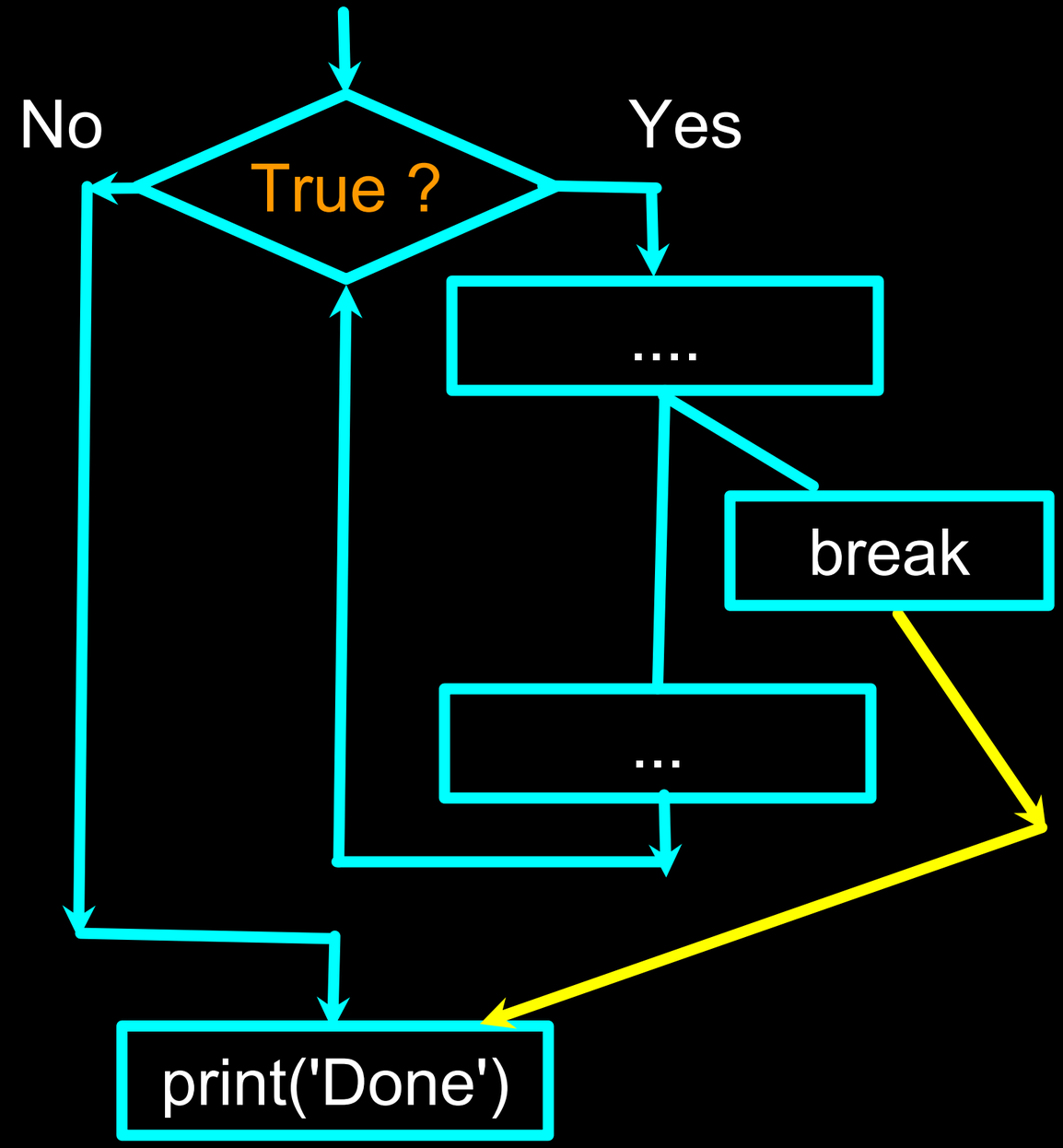
```
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```



```
> hello there
hello there
> finished
finished
> done
Done!
```

```
while True:
    line = input('> ')
    if line == 'done' :
        break
    print(line)
print('Done!')
```

http://en.wikipedia.org/wiki/Transporter_(Star_Trek)



Finishing an Iteration with continue

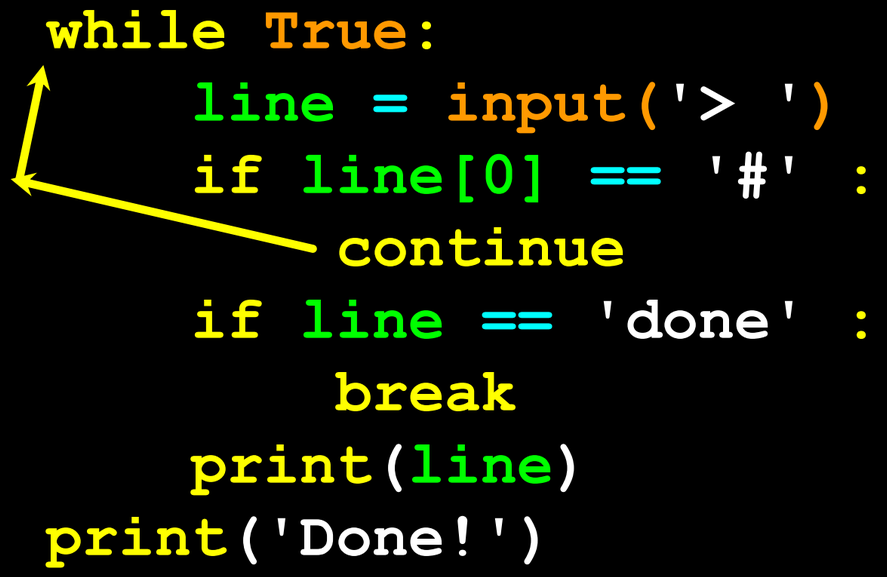
The continue statement ends the current iteration and jumps to the top of the loop and starts the next iteration

```
while True:
    line = input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> # don't print this
> print this!
print this!
> done
Done!
```

Finishing an Iteration with continue

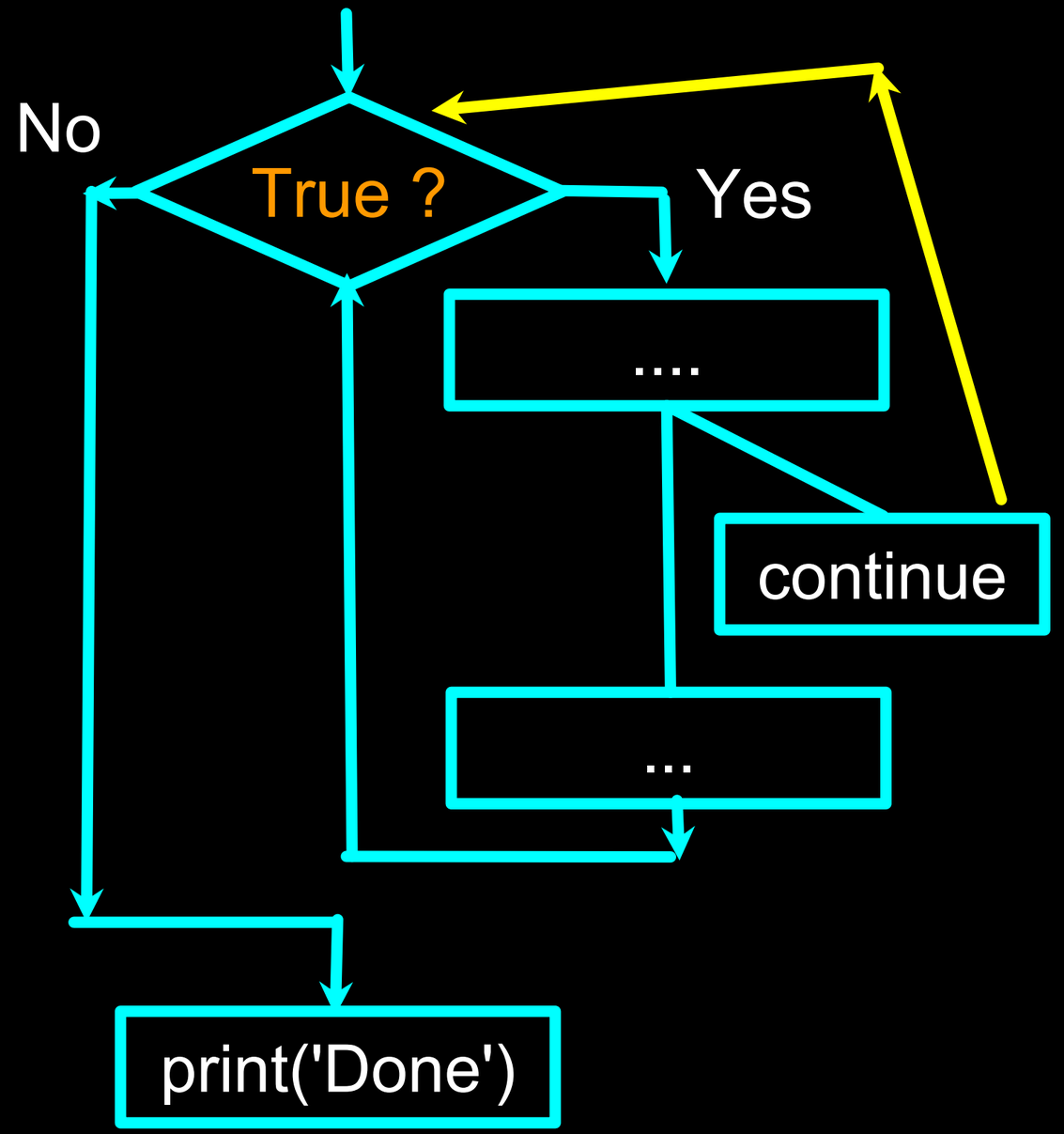
The continue statement ends the current iteration and jumps to the top of the loop and starts the next iteration



```
while True:
    line = input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```

```
> hello there
hello there
> # don't print this
> print this!
print this!
> done
Done!
```

```
while True:
    line = raw_input('> ')
    if line[0] == '#' :
        continue
    if line == 'done' :
        break
    print(line)
print('Done!')
```



Indefinite Loops

- While loops are called “indefinite loops” because they keep going until a logical condition becomes False
- The loops we have seen so far are pretty easy to examine to see if they will terminate or if they will be “infinite loops”
- Sometimes it is a little harder to be sure if a loop will terminate

Definite Loops

Iterating over a set of items…

Definite Loops

- Quite often we have a list of items of the lines in a file - effectively a finite set of things
- We can write a loop to run the loop once for each of the items in a set using the Python for construct
- These loops are called “definite loops” because they execute an exact number of times
- We say that “definite loops iterate through the members of a set”

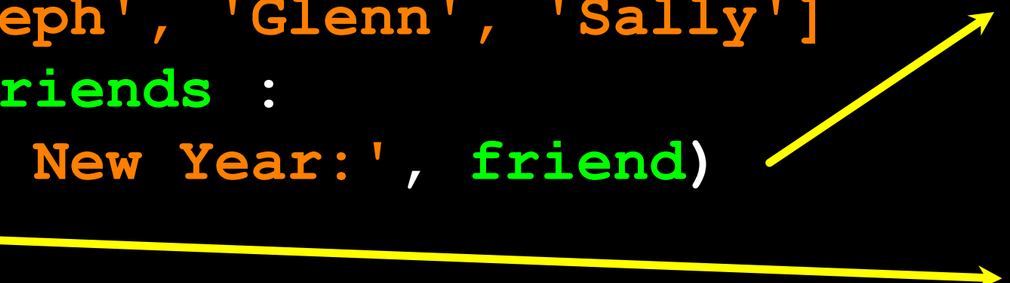
A Simple Definite Loop

```
for i in [5, 4, 3, 2, 1] :
    print(i)
print('Blastoff!')
```

```
5
4
3
2
1
Blastoff!
```

A Definite Loop with Strings

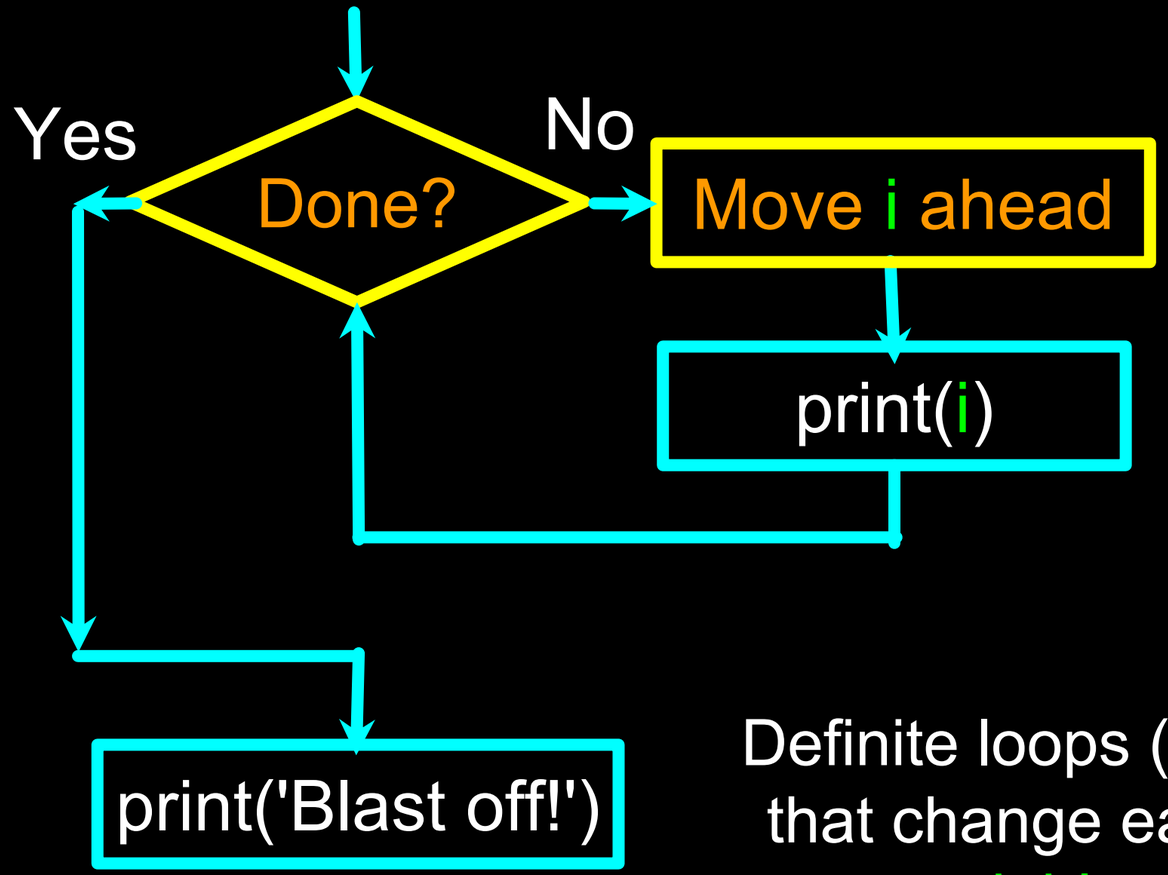
```
friends = ['Joseph', 'Glenn', 'Sally']
for friend in friends :
    print('Happy New Year:', friend)
print('Done!')
```



```
Happy New Year: Joseph
Happy New Year: Glenn
Happy New Year: Sally

Done!
```

A Simple Definite Loop



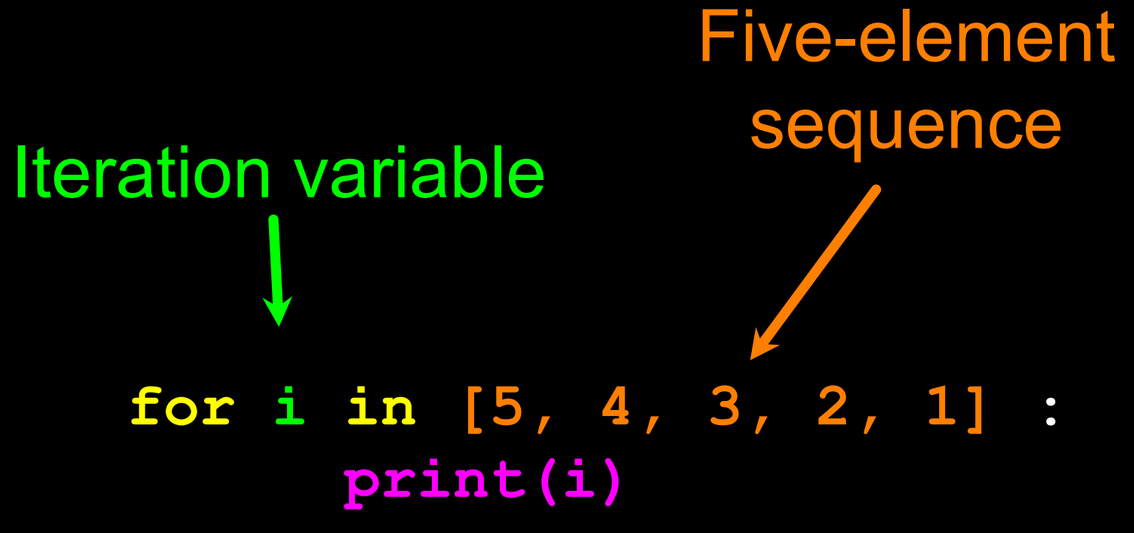

```
for i in [5, 4, 3, 2, 1] :
    print(i)
print('Blastoff!')
```

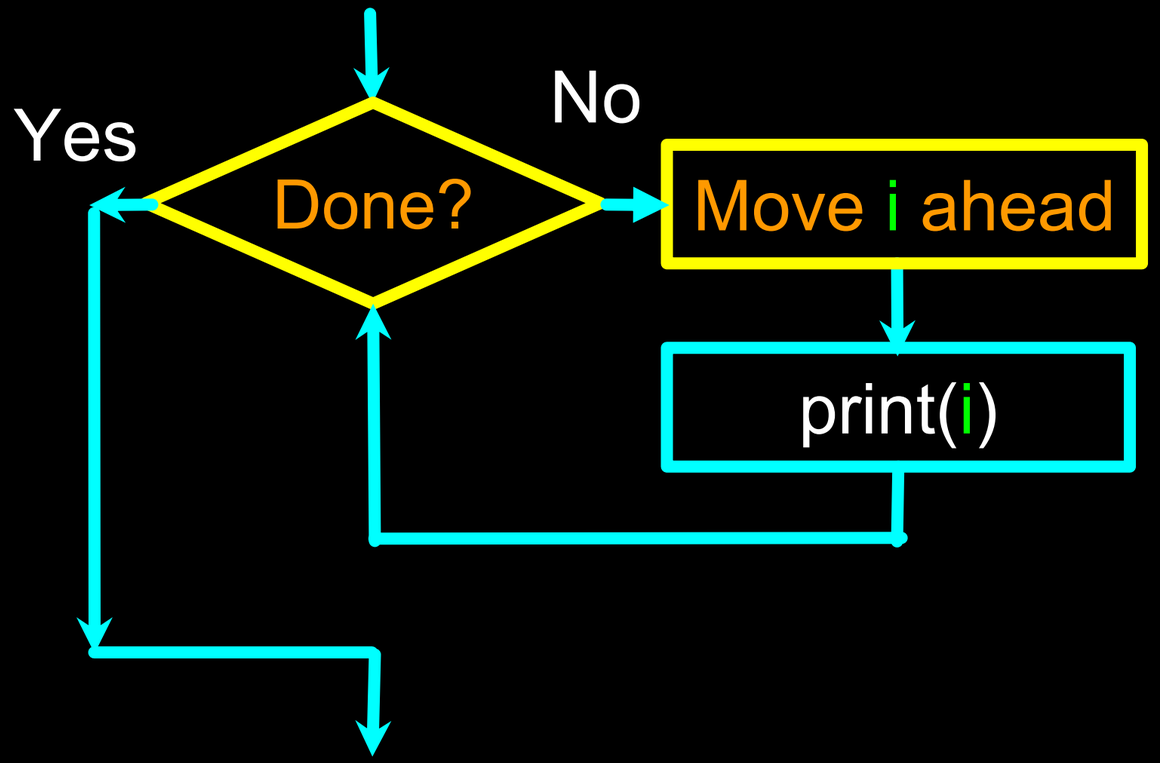
```
5
4
3
2
1
Blastoff!
```

Definite loops (for loops) have explicit iteration variables that change each time through a loop. These iteration variables move through the sequence or set.

Looking at in...

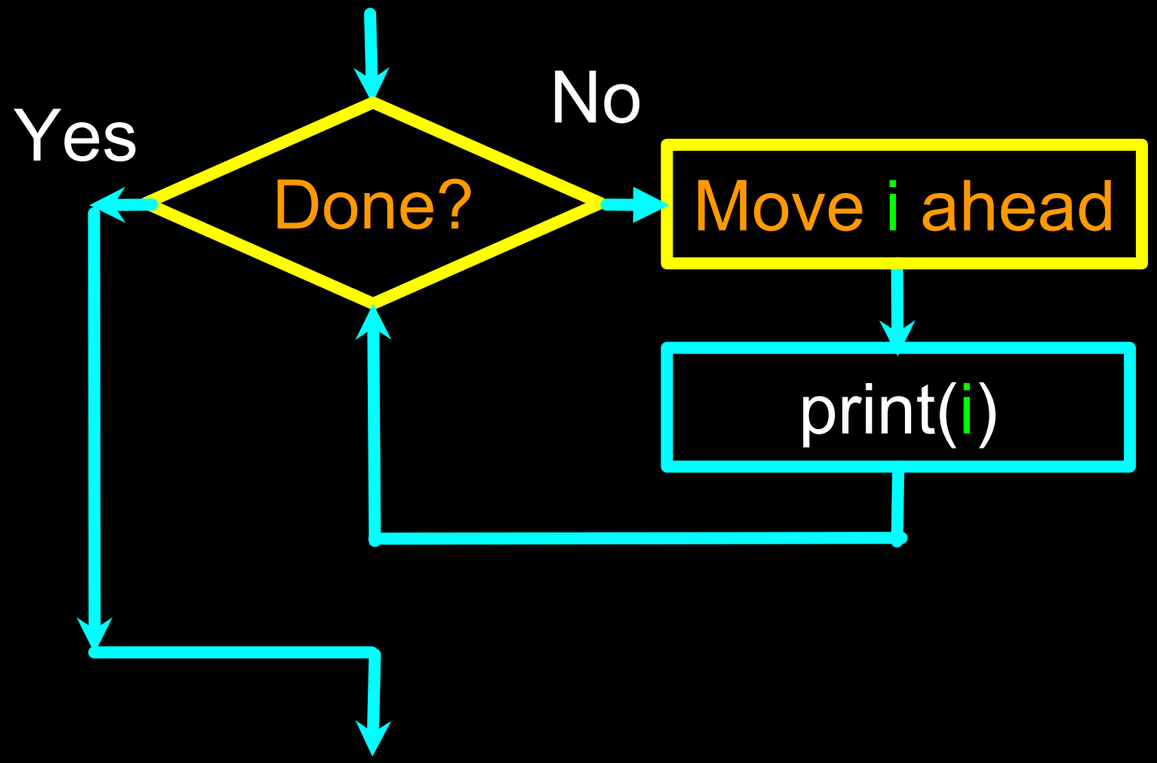
- The iteration variable "iterates" through the sequence (ordered set)
- The block (body) of code is executed once for each value in the sequence
- The iteration variable moves through all of the values in the sequence



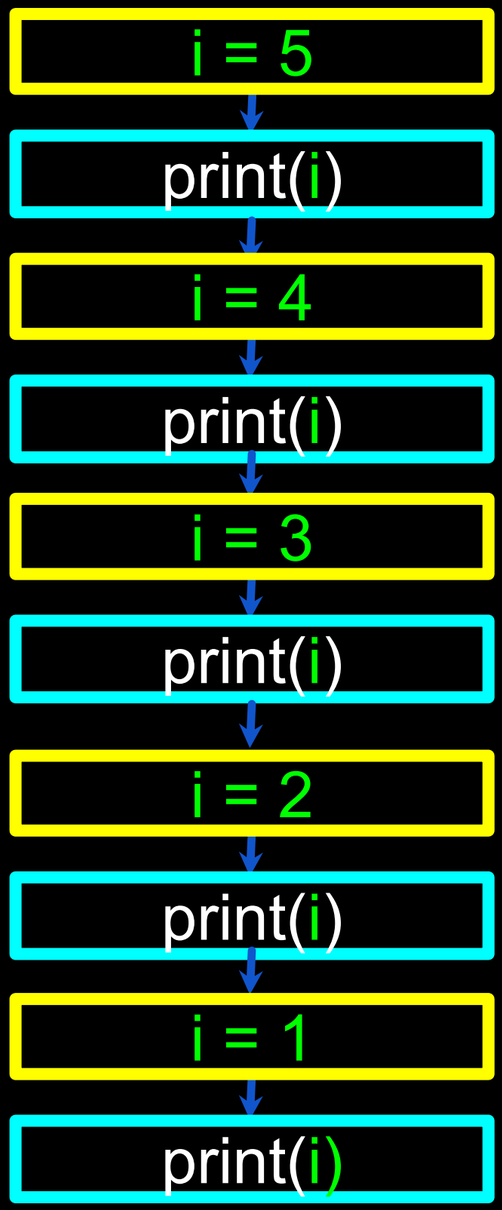



```
for i in [5, 4, 3, 2, 1] :
    print(i)
```

- The iteration variable “iterates” through the sequence (ordered set)
- The block (body) of code is executed once for each value in the sequence
- The iteration variable moves through all of the values in the sequence




```
for i in [5, 4, 3, 2, 1] :
    print(i)
```



Loop Idioms:
What We Do in Loops

Note: Even though these examples are simple, the patterns apply to all kinds of loops

Making “smart” loops

The trick is “knowing” something about the whole loop when you are stuck writing code that only sees one entry at a time

Set some variables to initial values

for thing in data:

Look for something or do something to each entry separately, updating a variable

Look at the variables

Looping Through a Set

```
print('Before')
for thing in [9, 41, 12, 3, 74, 15] :
     print(thing)
print('After')
```

```
$ python basicloop.py
Before
9
41
12
3
74
15
After
```

What is the Largest Number?

What is the Largest Number?

3

What is the Largest Number?

41

What is the Largest Number?

12

What is the Largest Number?

9

What is the Largest Number?

74

What is the Largest Number?

15

What is the Largest Number?

What is the Largest Number?

3 41 12 9 74 15

What is the Largest Number?

largest_so_far -1

What is the Largest Number?

3

largest_so_far 3

What is the Largest Number?

41

largest_so_far 41

What is the Largest Number?

12

largest_so_far 41

What is the Largest Number?

9

largest_so_far 41

What is the Largest Number?

74

largest_so_far 74

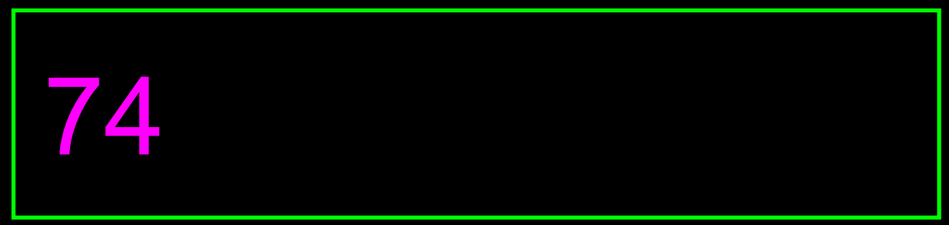
What is the Largest Number?

15

74

What is the Largest Number?

3 41 12 9 74 15



Finding the Largest Value

```
largest_so_far = -1
print('Before', largest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num > largest_so_far :
        largest_so_far = the_num
    print(largest_so_far, the_num)

print('After', largest_so_far)
```

```
$ python largest.py
Before -1
9  9
41  41
41 12
41  3
74  74
74  15
After 74
```

We make a variable that contains the largest value we have seen so far. If the current number we are looking at is larger, it is the new largest value we have seen so far.

More Loop Patterns…

Counting in a Loop

```
zork = 0
print('Before', zork)
for thing in [9, 41, 12, 3, 74, 15] :
    zork = zork + 1
    print(zork, thing)
print('After', zork)
```

```
$ python countloop.py
Before 0
1 9
2 41
3 12
4 3
5 74
6 15
After 6
```

To count how many times we execute a loop, we introduce a counter variable that starts at 0 and we add one to it each time through the loop.

Summing in a Loop

```
zork = 0
print('Before', zork)
for thing in [9, 41, 12, 3, 74, 15] :
    zork = zork + thing
    print(zork, thing)
print('After', zork)
```

```
$ python countloop.py
Before 0
9 9
50 41
62 12
65 3
139 74
154 15
After 154
```

To add up a value we encounter in a loop, we introduce a sum variable that starts at 0 and we add the value to the sum each time through the loop.

Finding the Average in a Loop

```
count = 0
sum = 0
print('Before', count, sum)
for value in [9, 41, 12, 3, 74, 15] :
    count = count + 1
    sum = sum + value
    print(count, sum, value)
print('After', count, sum, sum / count)
```

```
$ python averageloop.py
Before 0 0
1 9 9
2 50 41
3 62 12
4 65 3
5 139 74
6 154 15
After 6 154 25.666
```

An average just combines the counting and sum patterns and divides when the loop is done.

Filtering in a Loop

```
print('Before')
for value in [9, 41, 12, 3, 74, 15] :
    if value > 20:
        print('Large number',value)
print('After')
```

```
$ python search1.py
Before
Large number 41
Large number 74
After
```

We use an if statement in the loop to catch / filter the values we are looking for.

Search Using a Boolean Variable

```
found = False
print('Before', found)
for value in [9, 41, 12, 3, 74, 15] :
    if value == 3 :
        found = True
    print(found, value)
print('After', found)
```

```
$ python search1.py
Before False
False 9
False 41
False 12
True 3
True 74
True 15
After True
```

If we just want to search and know if a value was found, we use a variable that starts at False and is set to True as soon as we find what we are looking for.

How to Find the Smallest Value

```
largest_so_far = -1
print('Before', largest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num > largest_so_far :
        largest_so_far = the_num
    print(largest_so_far, the_num)

print('After', largest_so_far)
```

```
$ python largest.py
Before -1
9  9
41  41
41 12
41  3
74  74
74  15
After 74
```

How would we change this to make it find the smallest value in the list?

Finding the Smallest Value

```
smallest_so_far = -1
print('Before', smallest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num < smallest_so_far :
        smallest_so_far = the_num
    print(smallest_so_far, the_num)

print('After', smallest_so_far)
```

We switched the variable name to smallest_so_far and switched the > to <

Finding the Smallest Value

```
smallest_so_far = -1
print('Before', smallest_so_far)
for the_num in [9, 41, 12, 3, 74, 15] :
    if the_num < smallest_so_far :
        smallest_so_far = the_num
    print(smallest_so_far, the_num)

print('After', smallest_so_far)
```

```
$ python smallbad.py
Before -1
-1  9
-1  41
-1 12
-1  3
-1  74
-1  15
After -1
```

We switched the variable name to smallest_so_far and switched the > to <

Finding the Smallest Value

```
smallest = None
print('Before')
for value in [9, 41, 12, 3, 74, 15] :
    if smallest is None :
        smallest = value
    elif value < smallest :
        smallest = value
    print(smallest, value)
print('After', smallest)
```

```
$ python smallest.py
Before
9 9
9 41
9 12
3 3
3 74
3 15
After 3
```

We still have a variable that is the smallest so far. The first time through the loop smallest is None, so we take the first value to be the smallest.

The is and is not Operators

```
smallest = None
print('Before')
for value in [3, 41, 12, 9, 74, 15] :
    if smallest is None :
        smallest = value
    elif value < smallest :
        smallest = value
    print(smallest, value)

print('After', smallest)
```

- Python has an is operator that can be used in logical expressions
- Implies “is the same as”
- Similar to, but stronger than ==
- is not also is a logical operator

Summary

- While loops (indefinite)
- Infinite loops
- Using break
- Using continue
- None constants and variables
- For loops (definite)
- Iteration variables
- Loop idioms
- Largest or smallest

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translators here

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Strings

Chapter 6

Python for Everybody

www.py4e.com

String Data Type

- A string is a sequence of characters
- A string literal uses quotes 'Hello' or "Hello"
- For strings, + means “concatenate”
- When a string contains numbers, it is still a string
- We can convert numbers in a string into a number using int()

```
>>> str1 = "Hello"
>>> str2 = 'there'
>>> bob = str1 + str2
>>> print(bob)
Hellothere
>>> str3 = '123'
>>> str3 = str3 + 1
Traceback (most recent call
last):  File "<stdin>", line 1,
in <module>
TypeError: cannot concatenate
'str' and 'int' objects
>>> x = int(str3) + 1
>>> print(x)
124
>>>
```

Reading and Converting

- We prefer to read data in using strings and then parse and convert the data as we need
- This gives us more control over error situations and/or bad user input
- Input numbers must be converted from strings

```
>>> name = input('Enter:')
Enter:Chuck
>>> print(name)
Chuck
>>> apple = input('Enter:')
Enter:100
>>> x = apple - 10
Traceback (most recent call last):  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for -: 'str' and 'int'
>>> x = int(apple) - 10
>>> print(x)
90
```

Looking Inside Strings

- We can get at any single character in a string using an index specified in square brackets
- The index value must be an integer and starts at zero
- The index value can be an expression that is computed

b	a	n	a	n	a
0	1	2	3	4	5

```
>>> fruit = 'banana'
>>> letter = fruit[1]
>>> print(letter)
a
>>> x = 3
>>> w = fruit[x - 1]
>>> print(w)
n
```

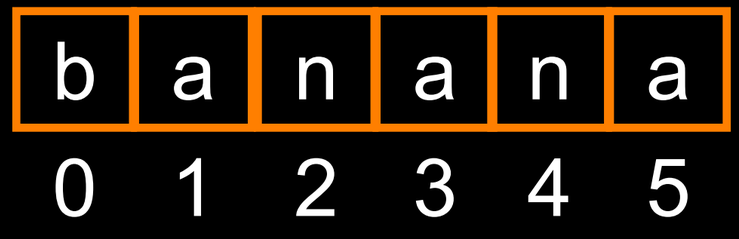
A Character Too Far

- You will get a python error if you attempt to index beyond the end of a string
- So be careful when constructing index values and slices

```
>>> zot = 'abc'
>>> print(zot[5])
Traceback (most recent call last):  File "<stdin>", line 1, in <module>
IndexError: string index out of range
>>>
```

Strings Have Length

The built-in function len gives us the length of a string

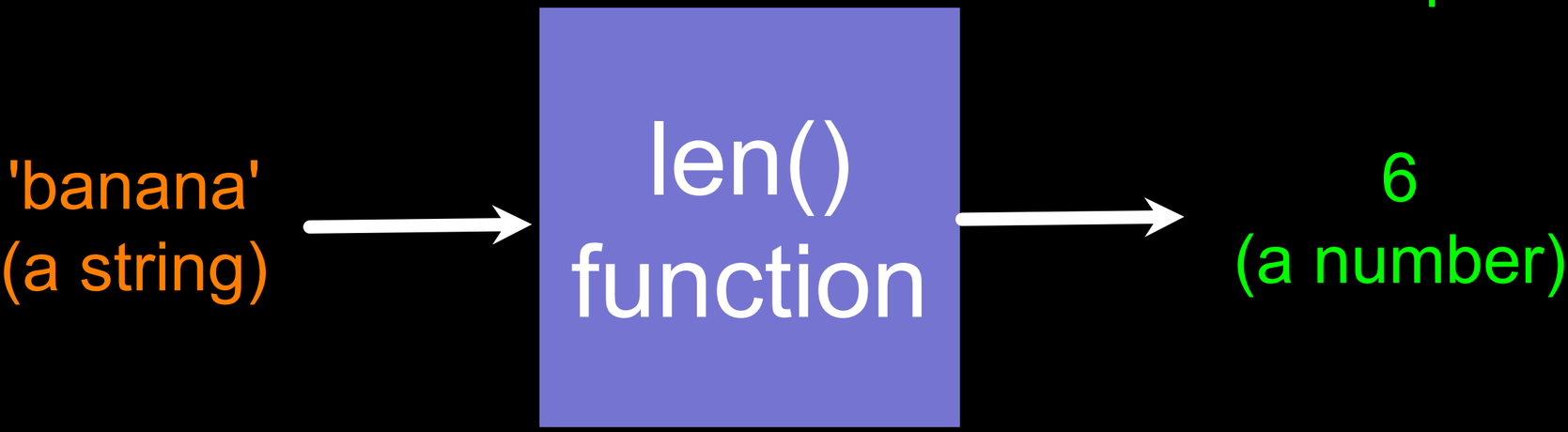



```
>>> fruit = 'banana'
>>> print(len(fruit))
6
```

len Function

```
>>> fruit = 'banana'
>>> x = len(fruit)
>>> print(x)
6
```

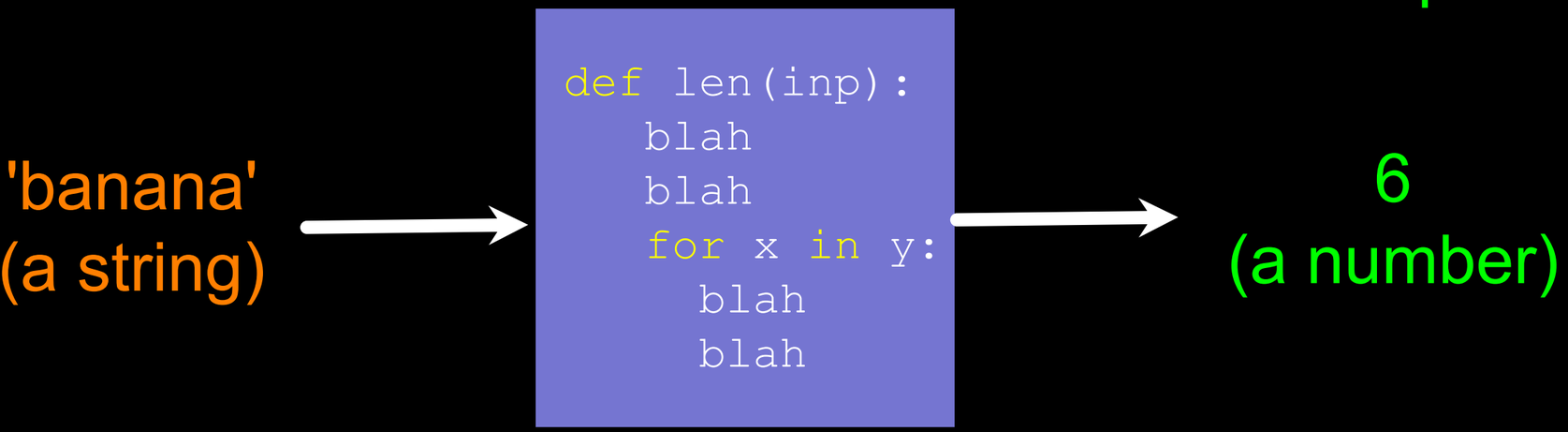
A function is some stored code that we use. A function takes some input and produces an output.



len Function

```
>>> fruit = 'banana'
>>> x = len(fruit)
>>> print(x)
6
```

A function is some stored code that we use. A function takes some input and produces an output.



Looping Through Strings

Using a while statement, an iteration variable, and the len function, we can construct a loop to look at each of the letters in a string individually

```
fruit = 'banana'
index = 0
while index < len(fruit):
    letter = fruit[index]
    print(index, letter)
    index = index + 1
```

```
0 b
1 a
2 n
3 a
4 n
5 a
```

Looping Through Strings

- A definite loop using a for statement is much more elegant
- The iteration variable is completely taken care of by the for loop

```
fruit = 'banana'
for letter in fruit:
    print(letter)
```

```
b
a
n
a
n
a
```

Looping Through Strings

- A definite loop using a for statement is much more elegant
- The iteration variable is completely taken care of by the for loop

```
fruit = 'banana'
for letter in fruit :
    print(letter)


index = 0
while index < len(fruit) :
    letter = fruit[index]
    print(letter)
    index = index + 1
```

```
b
a
n
a
n
a
```

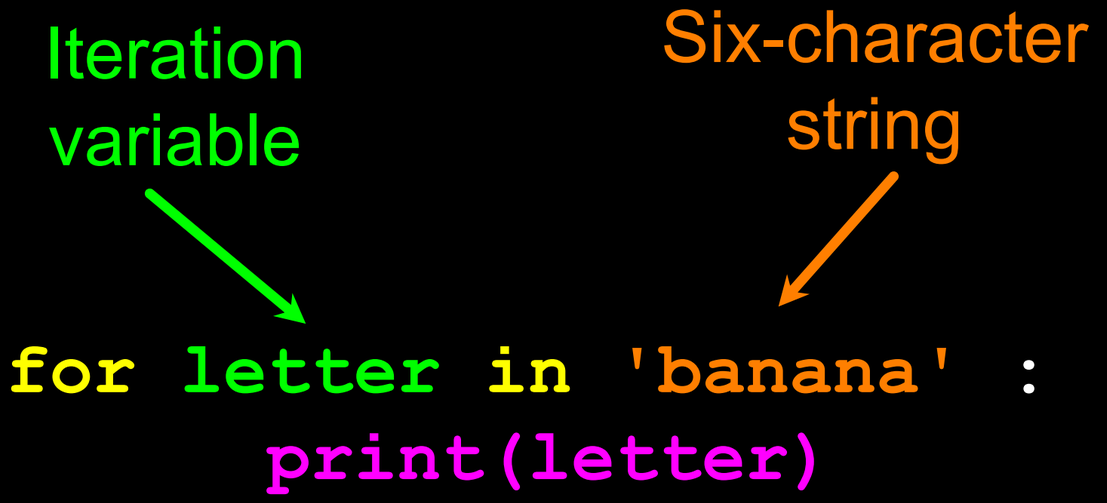
Looping and Counting

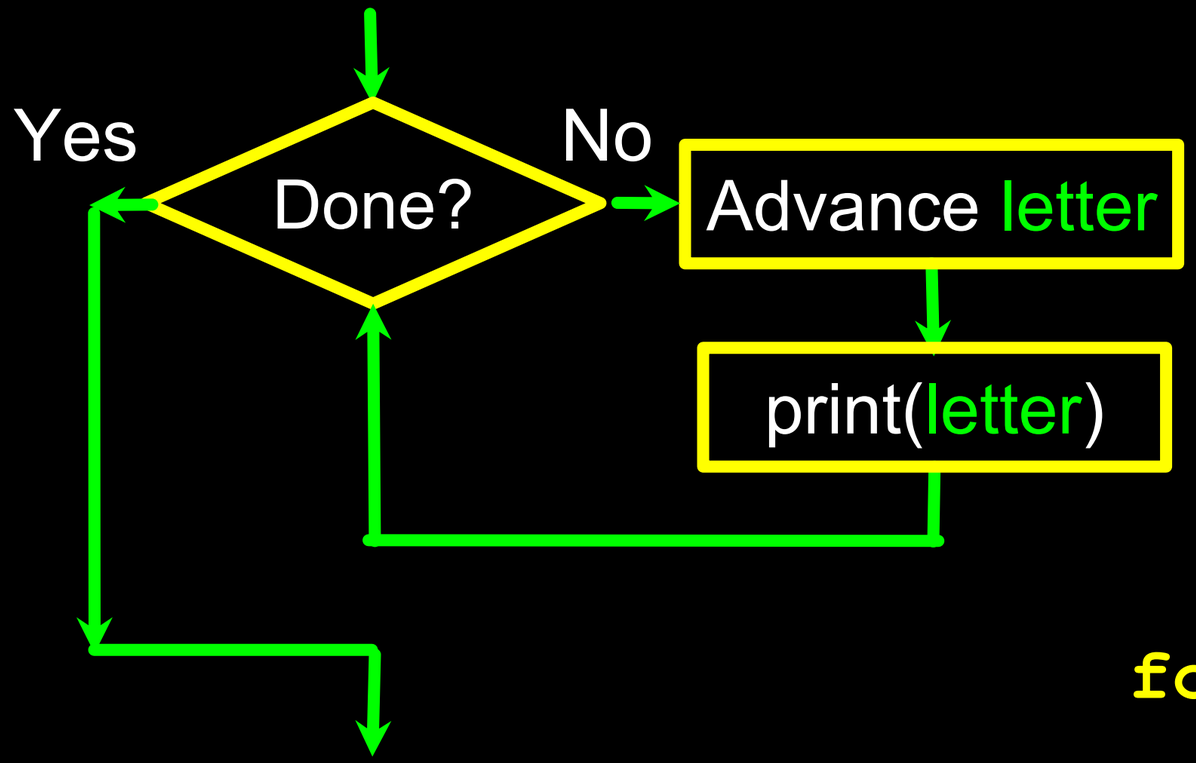
This is a simple loop that loops through each letter in a string and counts the number of times the loop encounters the 'a' character

```
word = 'banana'
count = 0
for letter in word :
    if letter == 'a' :
        count = count + 1
print(count)
```

Looking Deeper into in

- The iteration variable “iterates” through the sequence (ordered set)
- The block (body) of code is executed once for each value in the sequence
- The iteration variable moves through all of the values in the sequence





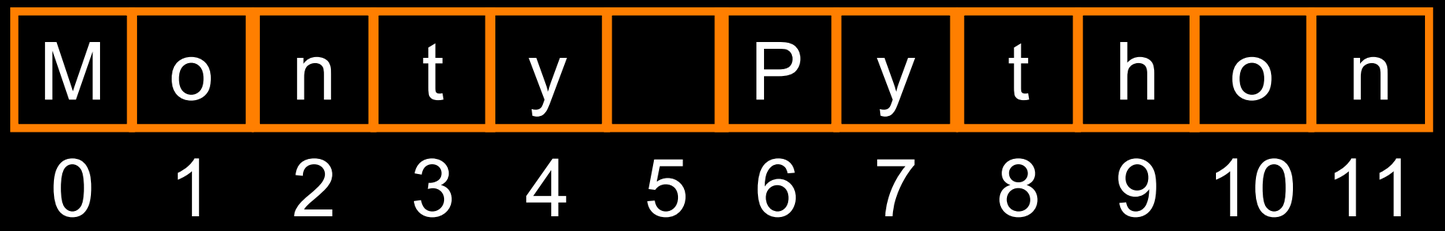
b	a	n	a	n	a

```
for letter in 'banana' :
    print(letter)
```

The iteration variable “iterates” through the string and the block (body) of code is executed once for each value in the sequence

More String Operations

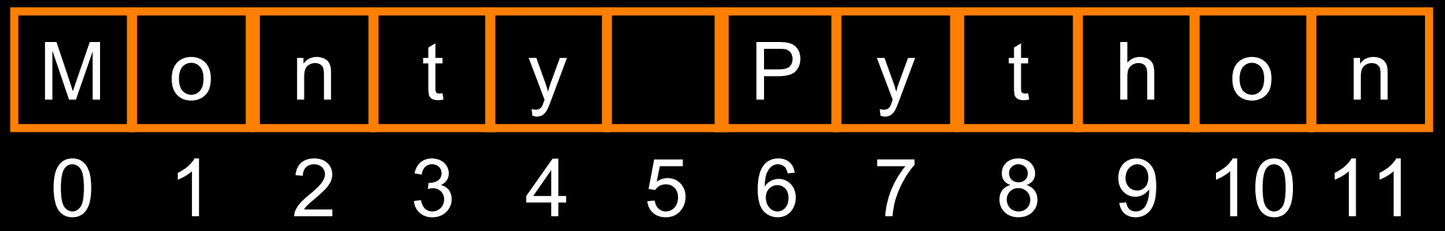
Slicing Strings



- We can also look at any continuous section of a string using a colon operator
- The second number is one beyond the end of the slice - “up to but not including”
- If the second number is beyond the end of the string, it stops at the end

```
>>> s = 'Monty Python'
>>> print(s[0:4])
Mont
>>> print(s[6:7])
P
>>> print(s[6:20])
Python
```

Slicing Strings



If we leave off the first number or the last number of the slice, it is assumed to be the beginning or end of the string respectively

```
>>> s = 'Monty Python'
>>> print(s[:2])
Mo
>>> print(s[8:])
thon
>>> print(s[:])
Monty Python
```

String Concatenation

When the + operator is applied to strings, it means "concatenation"

```
>>> a = 'Hello'
>>> b = a + 'There'
>>> print(b)
HelloThere
>>> c = a + ' ' + 'There'
>>> print(c)
Hello There
>>>
```

Using in as a Logical Operator

- The in keyword can also be used to check to see if one string is “in” another string
- The in expression is a logical expression that returns True or False and can be used in an if statement

```
>>> fruit = 'banana'
>>> 'n' in fruit
True
>>> 'm' in fruit
False
>>> 'nan' in fruit
True
>>> if 'a' in fruit :
...     print('Found it!')
...
Found it!
>>>
```

String Comparison

```
if word == 'banana':
    print('All right, bananas.')

if word < 'banana':
    print('Your word,' + word + ', comes before banana.')
elif word > 'banana':
    print('Your word,' + word + ', comes after banana.')
else:
    print('All right, bananas.')
```

String Library

- Python has a number of string functions which are in the string library
- These functions are already built into every string - we invoke them by appending the function to the string variable
- These functions do not modify the original string, instead they return a new string that has been altered

```
>>> greet = 'Hello Bob'
>>> zap = greet.lower()
>>> print(zap)
hello bob
>>> print(greet)
Hello Bob
>>> print('Hi There'.lower())
hi there
>>>
```

```
>>> stuff = 'Hello world'
>>> type(stuff)
<class 'str'>
>>> dir(stuff)
[...'capitalize', 'casefold', 'center', 'count', 'encode',
'endswith', 'expandtabs', 'find', 'format', 'format_map',
'index', 'isalnum', 'isalpha', 'isdecimal', 'isdigit',
'isidentifier', 'islower', 'isnumeric', 'isprintable', 'isspace',
'istitle', 'isupper', 'join', 'ljust', 'lower', 'lstrip',
'maketrans', 'partition', 'replace', 'rfind', 'rindex', 'rjust',
'rpartition', 'rsplit', 'rstrip', 'split', 'splitlines',
'startswith', 'strip', 'swapcase', 'title', 'translate', 'upper',
'zfill']
```

https://docs.python.org/3/library/stdtypes.html#string-methods

`str.`**`replace`**(*old*, *new*[, *count*])

Return a copy of the string with all occurrences of substring *old* replaced by *new*. If the optional argument *count* is given, only the first *count* occurrences are replaced.

`str.`**`rfind`**(*sub*[, *start*[, *end*]])

Return the highest index in the string where substring *sub* is found, such that *sub* is contained within `s[start:end]`. Optional arguments *start* and *end* are interpreted as in slice notation. Return `-1` on failure.

`str.`**`rindex`**(*sub*[, *start*[, *end*]])

Like `rfind()` but raises `ValueError` when the substring *sub* is not found.

`str.`**`rjust`**(*width*[, *fillchar*])

Return the string right justified in a string of length *width*. Padding is done using the specified *fillchar* (default is an ASCII space). The original string is returned if *width* is less than or equal to `len(s)`.

`str.`**`rpartition`**(*sep*)

Split the string at the last occurrence of *sep*, and return a 3-tuple containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return a 3-tuple containing two empty strings, followed by the string itself.

`str.`**`rsplit`**(*sep=None*, *maxsplit=-1*)

Return a list of the words in the string, using *sep* as the delimiter string. If *maxsplit* is given, at most *maxsplit* splits are done, the *rightmost* ones. If *sep* is not specified or `None`, any whitespace string is a separator. Except for splitting from the right, `rsplit()` behaves like `split()` which is described in detail below.

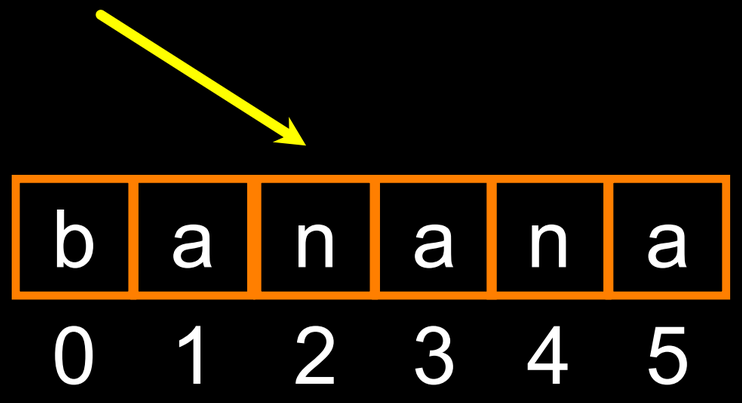
String Library

```
str.capitalize()
str.center(width[, fillchar])
str.endswith(suffix[, start[, end]])
str.find(sub[, start[, end]])
str.lstrip([chars])
```

```
str.replace(old, new[, count])
str.lower()
str.rstrip([chars])
str.strip([chars])
str.upper()
```

Searching a String

- We use the find() function to search for a substring within another string
- find() finds the first occurrence of the substring
- If the substring is not found, find() returns -1
- Remember that string position starts at zero




```
>>> fruit = 'banana'
>>> pos = fruit.find('na')
>>> print(pos)
2
>>> aa = fruit.find('z')
>>> print(aa)
-1
```

Making everything UPPER CASE

- You can make a copy of a string in lower case or upper case
- Often when we are searching for a string using find() we first convert the string to lower case so we can search a string regardless of case

```
>>> greet = 'Hello Bob'
>>> nnn = greet.upper()
>>> print(nnn)
HELLO BOB
>>> www = greet.lower()
>>> print(www)
hello bob
>>>
```

Search and Replace

- The replace() function is like a “search and replace” operation in a word processor
- It replaces all occurrences of the search string with the replacement string

```
>>> greet = 'Hello Bob'
>>> nstr = greet.replace('Bob','Jane')
>>> print(nstr)
Hello Jane
>>> nstr = greet.replace('o','X')
>>> print(nstr)
HellX BXb
>>>
```

Stripping Whitespace

- Sometimes we want to take a string and remove whitespace at the beginning and/or end
- lstrip() and rstrip() remove whitespace at the left or right
- strip() removes both beginning and ending whitespace

```
>>> greet = '   Hello Bob  '
>>> greet.lstrip()
'Hello Bob  '
>>> greet.rstrip()
'   Hello Bob'
>>> greet.strip()
'Hello Bob'
>>>
```

Prefixes

```
>>> line = 'Please have a nice day'
>>> line.startswith('Please')
True
>>> line.startswith('p')
False
```

Parsing and Extracting

21 31

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
>>> data = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
>>> atpos = data.find('@')
>>> print(atpos)
21
>>> sppos = data.find(' ',atpos)
>>> print(sppos)
31
>>> host = data[atpos+1 : sppos]
>>> print(host)
uct.ac.za
```

Two Kinds of Strings

```
Python 2.7.10
>>> x = '이광춘'
>>> type(x)
<type 'str'>
>>> x = u'이광춘'
>>> type(x)
<type 'unicode'>
>>>
```

```
Python 3.5.1
>>> x = '이광춘'
>>> type(x)
<class 'str'>
>>> x = u'이광춘'
>>> type(x)
<class 'str'>
>>>
```

In Python 3, all strings are Unicode

Summary

- String type
- Read/Convert
- Indexing strings []
- Slicing strings [2:4]
- Looping through strings with for and while
- Concatenating strings with +
- String operations
- String library
- String comparisons
- Searching in strings
- Replacing text
- Stripping white space

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translators here

...

Python Objects

Charles Severance

Python for Everybody
www.py4e.com

Warning

- This lecture is very much about definitions and mechanics for objects
- This lecture is a lot more about “how it works” and less about “how you use it”
- You won’t get the entire picture until this is all looked at in the context of a real problem
- So please suspend disbelief and learn technique for the next 40 or so slides…

5. Data Structures

This chapter describes some things you've learned about already in more detail, and adds some new things as well.

5.1. More on Lists

The list data type has some more methods. Here are all of the methods of list objects:

`list.`**`append`**`(x)`
Add an item to the end of the list. Equivalent to `a[len(a):] = [x]`.

`list.`**`extend`**`(L)`
Extend the list by appending all the items in the given list. Equivalent to `a[len(a):] = L`.

`list.`**`insert`**`(i, x)`
Insert an item at a given position. The first argument is the index of the element before which to insert, so `a.insert(0, x)` inserts at the front of the list, and `a.insert(len(a), x)` is equivalent to `a.append(x)`.

`list.`**`remove`**`(x)`
Remove the first item from the list whose value is *x*. It is an error if there is no such item.

`list.`**`pop`**`([i])`
Remove the item at the given position in the list, and return it. If no index is specified, `a.pop()` removes and returns the last item in the list. (The square brackets around the *i* in the method signature denote that the parameter is optional, not that you should type square brackets at that position. You will see this notation frequently in the Python Library Reference.)

https://docs.python.org/3/tutorial/datastructures.html

12.6. `sqlite3` — DB-API 2.0 interface for SQLite databases

Source code: Lib/sqlite3/

SQLite is a C library that provides a lightweight disk-based database that doesn't require a separate server process and allows accessing the database using a nonstandard variant of the SQL query language. Some applications can use SQLite for internal data storage. It's also possible to prototype an application using SQLite and then port the code to a larger database such as PostgreSQL or Oracle.

The sqlite3 module was written by Gerhard Häring. It provides a SQL interface compliant with the DB-API 2.0 specification described by PEP 249.

To use the module, you must first create a `Connection` object that represents the database. Here the data will be stored in the `example.db` file:

```
import sqlite3
conn = sqlite3.connect('example.db')
```

You can also supply the special name `:memory:` to create a database in RAM.

Once you have a `Connection`, you can create a `Cursor` object and call its `execute()` method to perform SQL commands:

```
c = conn.cursor()

# Create table
c.execute('''CREATE TABLE stocks
             (date text, trans text, symbol text, qty real, price real)''')
```

https://docs.python.org/3/library/sqlite3.html

Lets Start with Programs

```
inp = input('Europe floor?')
usf = int(inp) + 1
print('US floor', usf)
```

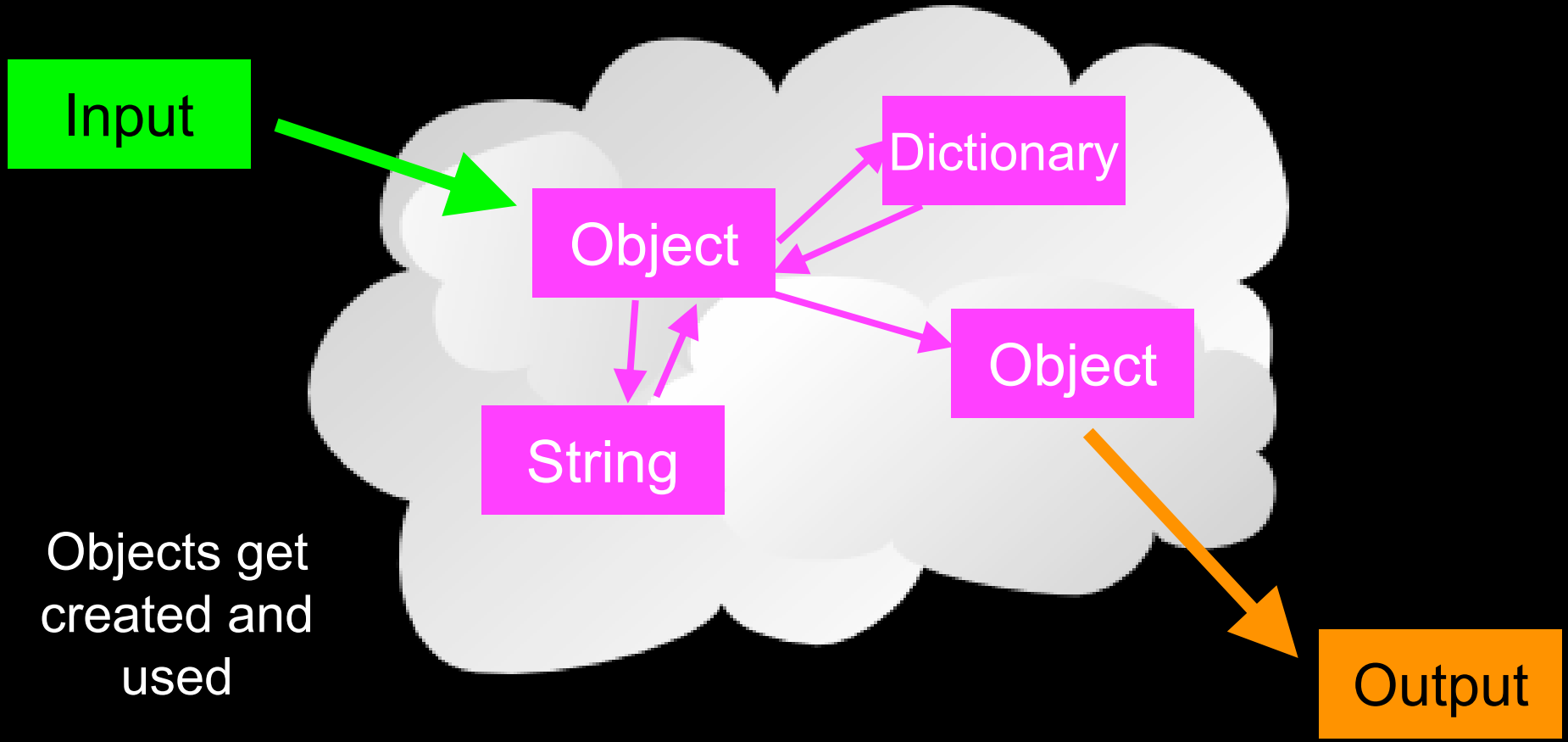
Europe floor? 0
US floor 1

Object Oriented

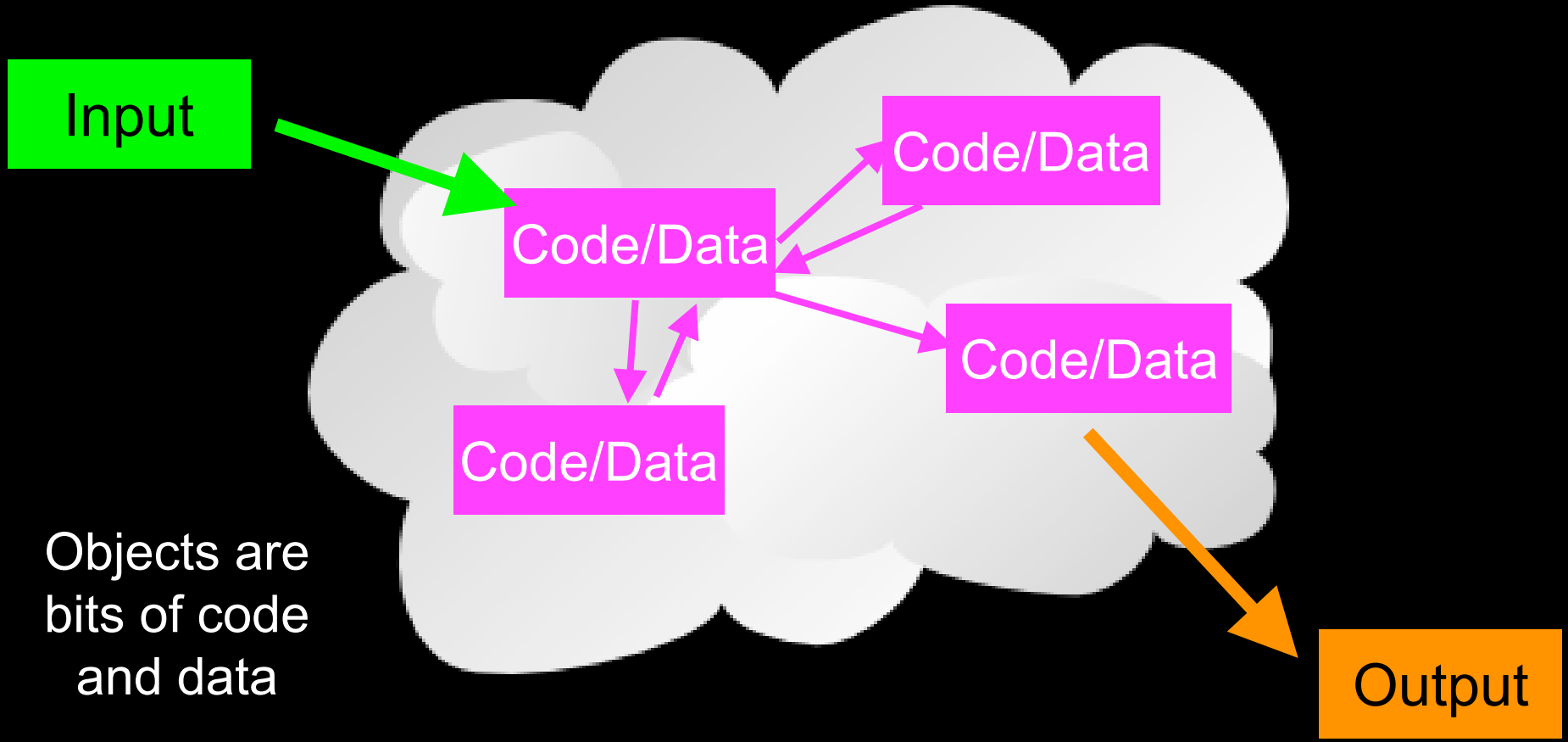
- A program is made up of many cooperating objects
- Instead of being the “whole program” - each object is a little “island” within the program and cooperatively working with other objects
- A program is made up of one or more objects working together - objects make use of each other’s capabilities

Object

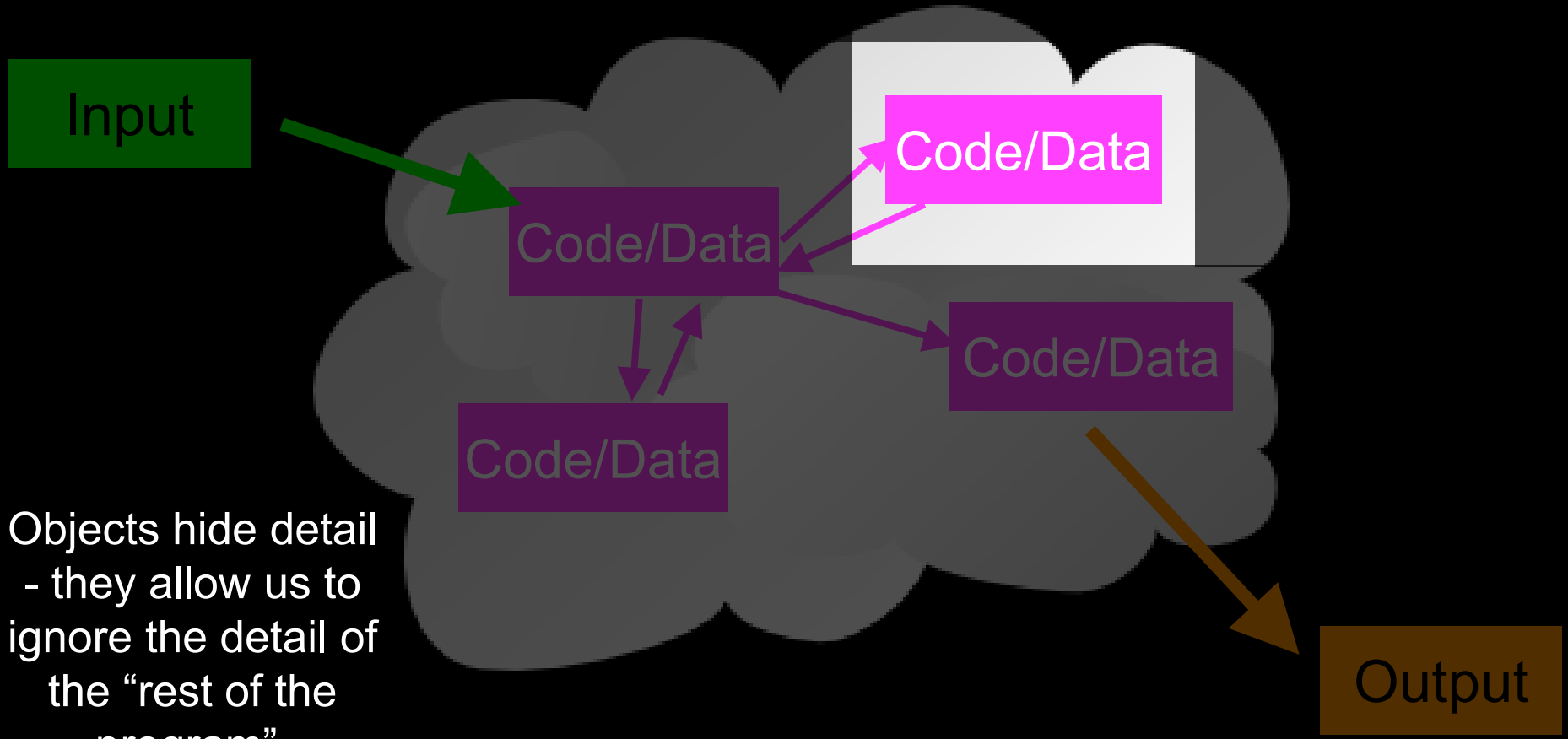
- An Object is a bit of self-contained Code and Data
- A key aspect of the Object approach is to break the problem into smaller understandable parts (divide and conquer)
- Objects have boundaries that allow us to ignore un-needed detail
- We have been using objects all along: String Objects, Integer Objects, Dictionary Objects, List Objects...



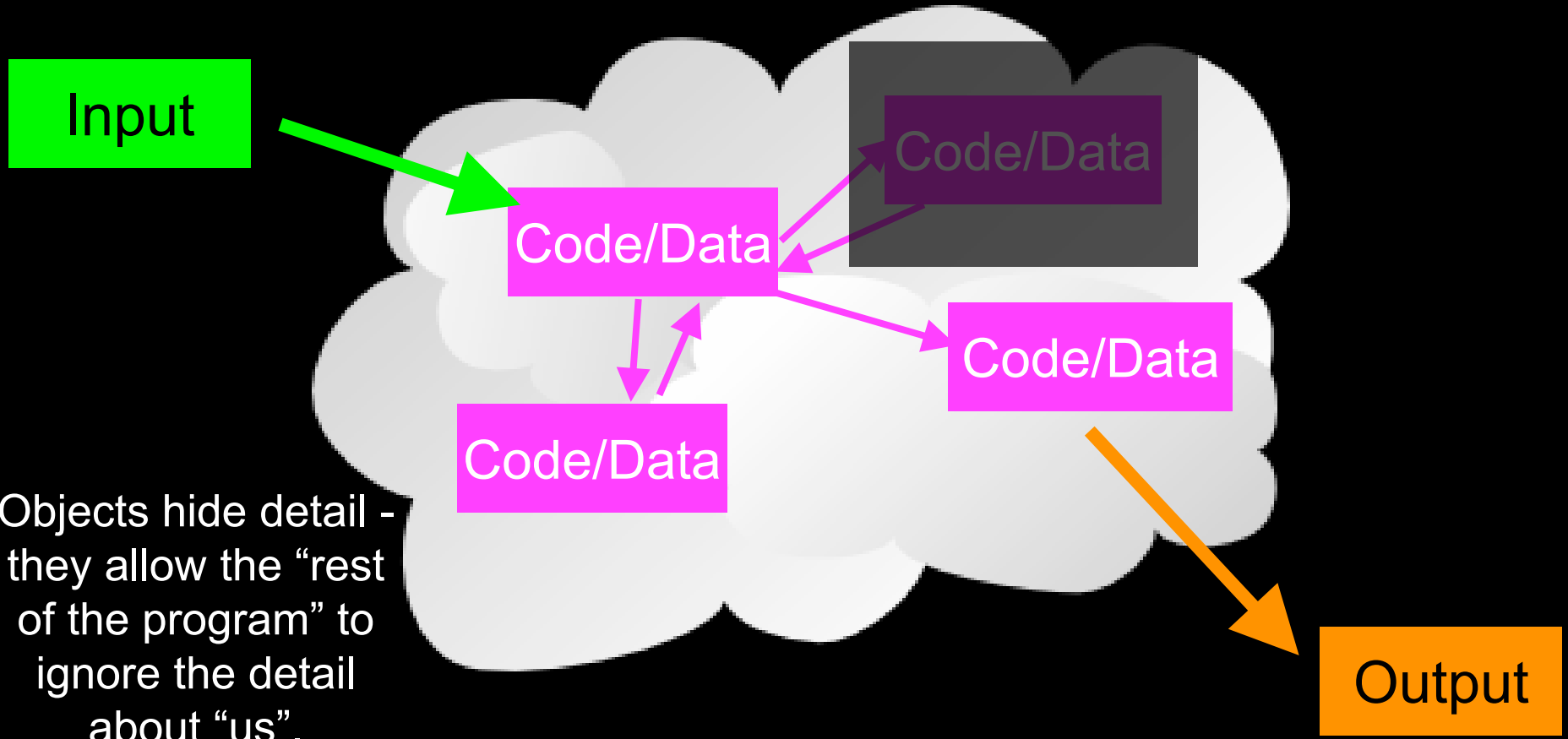
Objects get created and used



Objects are bits of code and data



Objects hide detail - they allow us to ignore the detail of the “rest of the program”.



Objects hide detail - they allow the “rest of the program” to ignore the detail about “us”.

Definitions

- Class - a template
- Method or Message - A defined capability of a class
- Field or attribute- A bit of data in a class
- Object or Instance - A particular instance of a class

Terminology: Class

Defines the abstract characteristics of a thing (object), including the thing's characteristics (its attributes, fields or properties) and the thing's behaviors (the things it can do, or methods, operations or features). One might say that a class is a blueprint or factory that describes the nature of something. For example, the class Dog would consist of traits shared by all dogs, such as breed and fur color (characteristics), and the ability to bark and sit (behaviors).

http://en.wikipedia.org/wiki/Object-oriented_programming

Terminology: Instance

One can have an instance of a class or a particular object. The instance is the actual object created at runtime. In programmer jargon, the Lassie object is an instance of the Dog class. The set of values of the attributes of a particular object is called its state. The object consists of state and the behavior that's defined in the object's class.

Object and Instance are often used interchangeably.

http://en.wikipedia.org/wiki/Object-oriented_programming

Terminology: Method

An object's abilities. In language, methods are verbs. Lassie, being a Dog, has the ability to bark. So bark() is one of Lassie's methods. She may have other methods as well, for example sit() or eat() or walk() or save_timmy(). Within the program, using a method usually affects only one particular object; all Dogs can bark, but you need only one particular dog to do the barking

Method and Message are often used interchangeably.

http://en.wikipedia.org/wiki/Object-oriented_programming

Some Python Objects

```
>>> x = 'abc'
>>> type(x)
<class 'str'>
>>> type(2.5)
<class 'float'>
>>> type(2)
<class 'int'>
>>> y = list()
>>> type(y)
<class 'list'>
>>> z = dict()
>>> type(z)
<class 'dict'>
```

```
>>> dir(x)
[ … 'capitalize', 'casefold', 'center', 'count',
'encode', 'endswith', 'expandtabs', 'find',
'format', … 'lower', 'lstrip', 'maketrans',
'partition', 'replace', 'rfind', 'rindex', 'rjust',
'rpartition', 'rsplit', 'rstrip', 'split',
'splitlines', 'startswith', 'strip', 'swapcase',
'title', 'translate', 'upper', 'zfill']
>>> dir(y)
[… 'append', 'clear', 'copy', 'count', 'extend',
'index', 'insert', 'pop', 'remove', 'reverse',
'sort']
>>> dir(z)
[…, 'clear', 'copy', 'fromkeys', 'get', 'items',
'keys', 'pop', 'popitem', 'setdefault', 'update',
'values']
```

A Sample Class

class is a reserved word that defines a template for making objects

Each PartyAnimal object has a bit of code

Tell the an object to run the party() code within it

```
class PartyAnimal:

  def __init(self)__:
    self.x = 0

  def party(self) :
    self.x = self.x + 1
    print("So far",self.x)

an = PartyAnimal()

an.party()
an.party()
an.party()
```

When the object is constructed, a specially named method is called to allocate and initialize attributes.

Construct a PartyAnimal object and store in an

PartyAnimal.party(an)

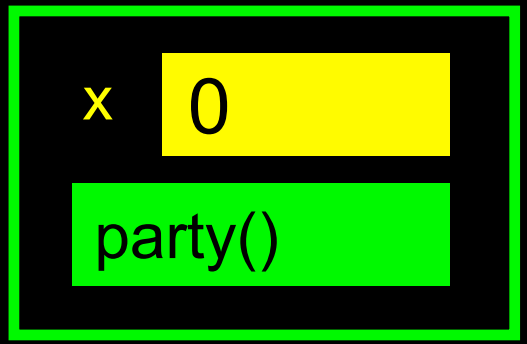
```
class PartyAnimal:

  def __init(self)__:
    self.x = 0

  def party(self) :
    self.x = self.x + 1
    print("So far",self.x)

an = PartyAnimal()

an.party()
an.party()
an.party()
```

$ python party2.py

```
class PartyAnimal:

  def __init(self)__:
    self.x = 0

  def party(self) :
    self.x = self.x + 1
    print("So far",self.x)

an = PartyAnimal()

an.party()
an.party()
an.party()
```

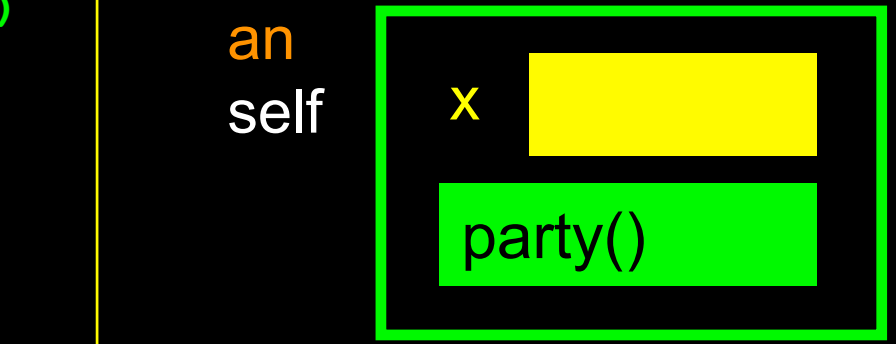
$ python party2.py

an



```
class PartyAnimal:

  def __init(self)__:
    self.x = 0

  def party(self) :
    self.x = self.x + 1
    print("So far",self.x)

an = PartyAnimal()

an.party()
an.party()
an.party()
```

```
$ python party2.py
So far 1
So far 2
So far 3
```



PartyAnimal.party(an)

Playing with dir() and type()

A Nerdy Way to Find Capabilities

- The dir() command lists capabilities
- Ignore the ones with underscores - these are used by Python itself
- The rest are real operations that the object can perform
- It is like type() - it tells us something *about* a variable

```
>>> y = list()
>>> type(y)
<class 'list'>
>>> dir(y)
['__add__', '__class__',
'__class_getitem__',
'__contains__', '__delattr__',
'__delitem__', '__dir__',
'__doc__', '__eq__', ...
'append', 'clear', 'copy',
'count', 'extend', 'index',
'insert', 'pop', 'remove',
'reverse', 'sort']
>>>
```

```
class PartyAnimal:

    def __init__(self):
      self.x = 0

    def party(self) :
      self.x = self.x + 1
      print("So far",self.x)

an = PartyAnimal()

print("Type", type(an))
print("Dir ", dir(an))
print ("Type", type(an.x))
print ("Type", type(an.party))
```

We can use dir() to find the “capabilities” of our newly created class.

```
$ python party3.py
Type <class '__main__.PartyAnimal'>
Dir  ['__class__', ... 'party', 'x']
Type <class 'int'>
Type <class 'method'>
```

party3.py

Try dir() with a String

```
>>> x = 'Hello there'
>>> dir(x)
['__add__', '__class__', '__contains__', '__delattr__',
'__dir__', '__doc__', '__eq__', '__format__', '__ge__',
'__getattribute__', '__getitem__', '__getnewargs__',
'__getstate__', '__gt__', '__hash__', '__init__',
'__init_subclass__', ...'capitalize', 'casefold', 'center',
'count', 'encode', 'endswith', 'expandtabs', 'find', 'format',
'format_map', 'index', 'isalnum', 'isalpha', 'isascii',
'isdecimal', 'isdigit', 'isidentifier', 'islower', 'isnumeric',
'isprintable', 'isspace', 'istitle', 'isupper', 'removesuffix',
'replace', 'rfind', 'rindex', 'rjust', 'rpartition', 'rsplit',
'rstrip', 'split', 'splitlines', 'startswith', 'strip',
'swapcase', 'title', 'translate', 'upper', 'zfill']
```

Object Lifecycle

http://en.wikipedia.org/wiki/Constructor_(computer_science)

Object Lifecycle

- Objects are created, used, and discarded
- We have special blocks of code (methods) that get called
  - At the moment of creation (constructor)
  - At the moment of destruction (destructor)
- Constructors are used a lot
- Destructors are seldom used

Constructor

The primary purpose of the constructor is to set up some instance variables to have the proper initial values when the object is created

```
class PartyAnimal:

    def __init__(self):
      self.x = 0
      print('I am constructed')

    def party(self) :
      self.x = self.x + 1
      print('So far',self.x)

    def __del__(self):
      print('I am destructed', self.x)

an = PartyAnimal()
an.party()
an.party()
an = 42
print('an contains',an)
```

```
$ python party4.py
I am constructed
So far 1
So far 2
I am destructed 2
an contains 42
```

The constructor and destructor are optional. The constructor is typically used to set up variables. The destructor is seldom used.

Constructor

In object oriented programming, a constructor in a class is a special block of statements called when an object is created

http://en.wikipedia.org/wiki/Constructor_(computer_science)

Many Instances

- We can create lots of objects - the class is the template for the object
- We can store each distinct object in its own variable
- We call this having multiple instances of the same class
- Each instance has its own copy of the instance variables

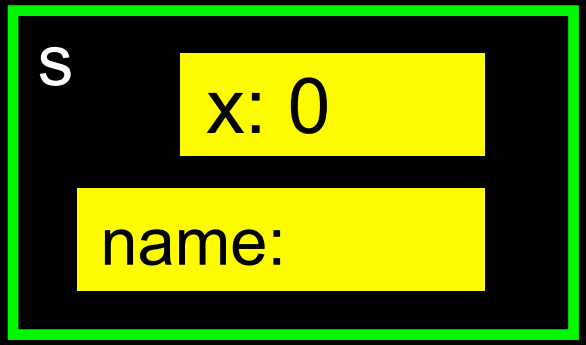
```
class PartyAnimal:

    def __init__(self, z):
      self.x = 0
      self.name = z
      print(self.name,"constructed")

    def party(self) :
      self.x = self.x + 1
      print(self.name,"party count",self.x)

s = PartyAnimal("Sally")
s.party()
j = PartyAnimal("Jim")

j.party()
s.party()
```

Constructors can have additional parameters. These can be used to set up instance variables for the particular instance of the class (i.e., for the particular object).

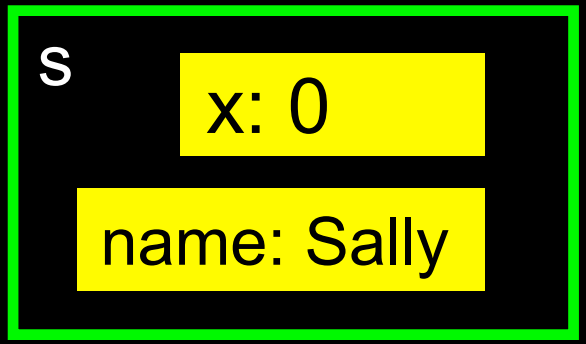
party5.py

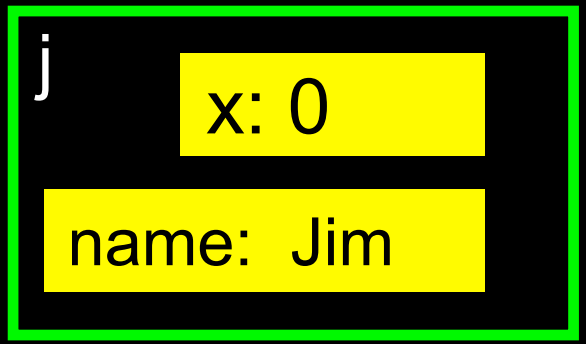
```
class PartyAnimal:

   def __init__(self, z):
     self.x = 0
     self.name = z
     print(self.name,"constructed")

   def party(self) :
     self.x = self.x + 1
     print(self.name,"party count",self.x)

s = PartyAnimal("Sally")
s.party()
j = PartyAnimal("Jim")

j.party()
s.party()
```

```
class PartyAnimal:

    def __init__(self, z):
      self.x = 0
      self.name = z
      print(self.name,"constructed")

    def party(self) :
      self.x = self.x + 1
      print(self.name,"party count",self.x)

s = PartyAnimal("Sally")
s.party()
j = PartyAnimal("Jim")

j.party()
s.party()
```



```
class PartyAnimal:

    def __init__(self, z):
      self.x = 0
      self.name = z
      print(self.name,"constructed")

    def party(self) :
      self.x = self.x + 1
      print(self.name,"party count",self.x)

s = PartyAnimal("Sally")
s.party()
j = PartyAnimal("Jim")

j.party()
s.party()
```





```
class PartyAnimal:

    def __init__(self, z):
      self.x = 0
      self.name = z
      print(self.name,"constructed")

    def party(self) :
      self.x = self.x + 1
      print(self.name,"party count",self.x)

s = PartyAnimal("Sally")
s.party()
j = PartyAnimal("Jim")

j.party()
s.party()
```

```
Sally constructed
Sally party count 1
Jim constructed
Jim party count 1
Sally party count 2
```

Inheritance

http://www.ibiblio.org/g2swap/byteofpython/read/inheritance.html

Inheritance

- When we make a new class - we can reuse an existing class and inherit all the capabilities of an existing class and then add our own little bit to make our new class
- Another form of store and reuse
- Write once - reuse many times
- The new class (child) has all the capabilities of the old class (parent) - and then some more

Terminology: Inheritance

‘Subclasses’ are more specialized versions of a class, which inherit attributes and behaviors from their parent classes, and can introduce their own.

http://en.wikipedia.org/wiki/Object-oriented_programming

```
class PartyAnimal:

   def __init__(self, nam):
     self.x = 0
     self.name = nam
     print(self.name,"constructed")

   def party(self) :
     self.x = self.x + 1
     print(self.name,"party count",self.x)

class FootballFan(PartyAnimal):

   def __init__(self, nam) :
       super().__init__(nam)
       self.points = 0

   def touchdown(self):
      self.points = self.points + 7
      self.party()
      print(self.name,"points",self.points)
```

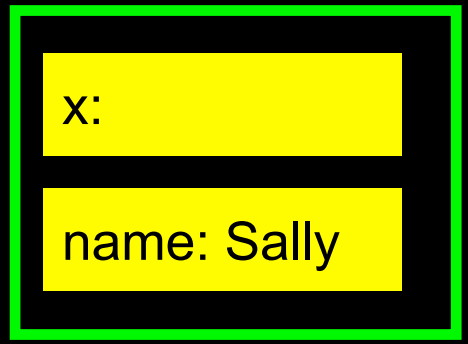
```
s = PartyAnimal("Sally")
s.party()

j = FootballFan("Jim")
j.party()
j.touchdown()
```

FootballFan is a class which extends PartyAnimal. It has all the capabilities of PartyAnimal and more.

party7.py

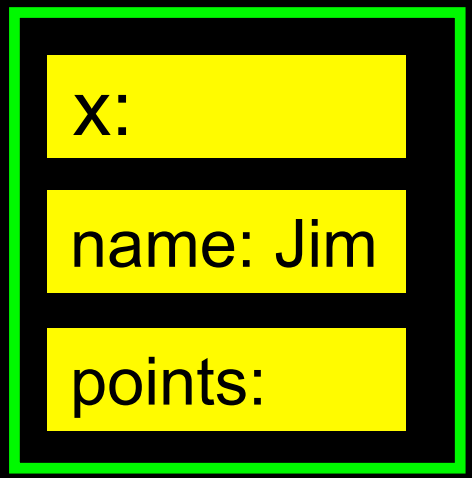
```
class PartyAnimal:

   def __init__(self, nam):
     self.x = 0
     self.name = nam
     print(self.name,"constructed")

   def party(self) :
     self.x = self.x + 1
     print(self.name,"party count",self.x)

class FootballFan(PartyAnimal):

   def __init__(self, nam) :
       super().__init__(nam)
       self.points = 0

   def touchdown(self):
      self.points = self.points + 7
      self.party()
      print(self.name,"points",self.points)
```

```
s = PartyAnimal("Sally")
s.party()

j = FootballFan("Jim")
j.party()
j.touchdown()
```



```
class PartyAnimal:

   def __init__(self, nam):
     self.x = 0
     self.name = nam
     print(self.name,"constructed")

   def party(self) :
     self.x = self.x + 1
     print(self.name,"party count",self.x)

class FootballFan(PartyAnimal):

   def __init__(self, nam) :
       super().__init__(nam)
       self.points = 0

   def touchdown(self):
      self.points = self.points + 7
      self.party()
      print(self.name,"points",self.points)
```

```
s = PartyAnimal("Sally")
s.party()

j = FootballFan("Jim")
j.party()
j.touchdown()
```



Definitions

- Class - a template
- Attribute – A variable within a class
- Method - A function within a class
- Object - A particular instance of a class
- Constructor – Code that runs when an object is created
- Inheritance - The ability to extend a class to make a new class.

Summary

- Object Oriented programming is a very structured approach to code reuse
- We can group data and functionality together and create many independent instances of a class

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors here

...

Additional Source Information

- Snowman Cookie Cutter" by Didriks is licensed under CC https://www.flickr.com/photos/dinnerseries/23570475099

- Photo from the television program *Lassie*. Lassie watches as Jeff (Tommy Rettig) works on his bike is

  https://en.wikipedia.org/wiki/Lassie#/media/File:Lassie_and_Tommy_Rettig_1956.JPG

Python Lists

Chapter 8

Python for Everybody
www.py4e.com

Programming

- Algorithm
  - A set of rules or steps used to solve a problem

- Data Structure
  - A particular way of organizing data in a computer

https://en.wikipedia.org/wiki/Algorithm
https://en.wikipedia.org/wiki/Data_structure

What is Not a “Collection”?

Most of our variables have one value in them - when we put a new value in the variable, the old value is overwritten

```
$ python
>>> x = 2
>>> x = 4
>>> print(x)
4
```

A List is a Kind of Collection

- A collection allows us to put many values in a single “variable”
- A collection is nice because we can carry all many values around in one convenient package.

```
friends = [ 'Joseph', 'Glenn', 'Sally' ]

carryon = [ 'socks', 'shirt', 'perfume' ]
```

List Constants

- List constants are surrounded by square brackets and the elements in the list are separated by commas
- A list element can be any Python object - even another list
- A list can be empty

```
>>> print([1, 24, 76])
[1, 24, 76]
>>> print(['red', 'yellow',
'blue'])
['red', 'yellow', 'blue']
>>> print(['red', 24, 98.6])
['red', 24, 98.6]
>>> print([ 1, [5, 6], 7])
[1, [5, 6], 7]
>>> print([])
[]
```

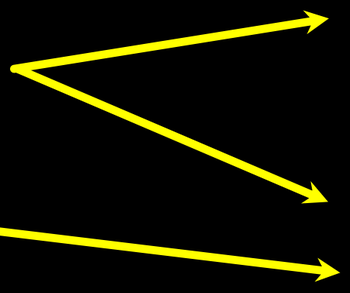
We Already Use Lists!

```
for i in [5, 4, 3, 2, 1] :
    print(i)
print('Blastoff!')
```

```
5
4
3
2
1
Blastoff!
```

Lists and Definite Loops - Best Pals

```
friends = ['Joseph', 'Glenn', 'Sally']
for friend in friends :
    print('Happy New Year:',  friend)
print('Done!')
```



```
Happy New Year: Joseph
Happy New Year: Glenn
Happy New Year: Sally
Done!
```

```
z = ['Joseph', 'Glenn', 'Sally']
for x in z:
    print('Happy New Year:',  x)
print('Done!')
```

Looking Inside Lists

Just like strings, we can get at any single element in a list using an index specified in square brackets

```
>>> friends = [ 'Joseph', 'Glenn', 'Sally' ]
>>> print(friends[1])
Glenn
>>>
```

Lists are Mutable

- Strings are “immutable” - we cannot change the contents of a string - we must make a new string to make any change
- Lists are “mutable” - we can change an element of a list using the index operator

```
>>> fruit = 'Banana'
>>> fruit[0] = 'b'
Traceback
TypeError: 'str' object does not
support item assignment
>>> x = fruit.lower()
>>> print(x)
banana
>>> lotto = [2, 14, 26, 41, 63]
>>> print(lotto)
[2, 14, 26, 41, 63]
>>> lotto[2] = 28
>>> print(lotto)
[2, 14, 28, 41, 63]
```

How Long is a List?

- The len() function takes a list as a parameter and returns the number of elements in the list
- Actually len() tells us the number of elements of any set or sequence (such as a string...)

```
>>> greet = 'Hello Bob'
>>> print(len(greet))
9
>>> x = [ 1, 2, 'joe', 99]
>>> print(len(x))
4
>>>
```

Using the range Function

- The range function returns a list of numbers that range from zero to one less than the parameter
- We can construct an index loop using for and an integer iterator

```
>>> print(range(4))
[0, 1, 2, 3]
>>> friends = ['Joseph', 'Glenn', 'Sally']
>>> print(len(friends))
3
>>> print(list(range(len(friends))))
[0, 1, 2]
>>>
```

A Tale of Two Loops...

```
friends = ['Joseph', 'Glenn', 'Sally']

for friend in friends :
    print('Happy New Year:',  friend)

for i in range(len(friends)) :
    friend = friends[i]
    print('Happy New Year:',  friend)
```

```
>>> friends = ['Joseph', 'Glenn', 'Sally']
>>> print(len(friends))
3
>>> print(list(range(len(friends))))
[0, 1, 2]
>>>
```

Happy New Year: Joseph

Happy New Year: Glenn

Happy New Year: Sally

Concatenating Lists Using +

We can create a new list by adding two existing lists together

```
>>> a = [1, 2, 3]
>>> b = [4, 5, 6]
>>> c = a + b
>>> print(c)
[1, 2, 3, 4, 5, 6]
>>> print(a)
[1, 2, 3]
```

Lists Can Be Sliced Using :

```
>>> t = [9, 41, 12, 3, 74, 15]
>>> t[1:3]
[41,12]
>>> t[:4]
[9, 41, 12, 3]
>>> t[3:]
[3, 74, 15]
>>> t[:]
[9, 41, 12, 3, 74, 15]
```

Remember: Just like in strings, the second number is “up to but not including”

List Methods

```
>>> x = list()
>>> type(x)
<type 'list'>
>>> dir(x)
[... 'append', 'count', 'extend', 'index', 'insert',
'pop', 'remove', 'reverse', 'sort']
>>>
```

http://docs.python.org/tutorial/datastructures.html

Building a List from Scratch

- We can create an empty list and then add elements using the append method
- The list stays in order and new elements are added at the end of the list

```
>>> stuff = list()
>>> stuff.append('book')
>>> stuff.append(99)
>>> print(stuff)
['book', 99]
>>> stuff.append('cookie')
>>> print(stuff)
['book', 99, 'cookie']
```

Is Something in a List?

- Python provides two operators that let you check if an item is in a list
- These are logical operators that return True or False
- They do not modify the list

```
>>> some = [1, 9, 21, 10, 16]
>>> 9 in some
True
>>> 15 in some
False
>>> 20 not in some
True
>>>
```

Lists are in Order

- A list can hold many items and keeps those items in the order until we do something to change the order
- A list can be sorted (i.e., change its order)
- The sort method (unlike in strings) means “sort yourself”

```
>>> friends = [ 'Joseph', 'Glenn', 'Sally' ]
>>> friends.sort()
>>> print(friends)
['Glenn', 'Joseph', 'Sally']
>>> print(friends[1])
Joseph
>>>
```

Built-in Functions and Lists

- There are a number of functions built into Python that take lists as parameters
- Remember the loops we built? These are much simpler.

```
>>> nums = [3, 41, 12, 9, 74, 15]
>>> print(len(nums))
6
>>> print(max(nums))
74
>>> print(min(nums))
3
>>> print(sum(nums))
154
>>> print(sum(nums)/len(nums))
25.6
```

```
total = 0
count = 0
while True :
    inp = input('Enter a number: ')
    if inp == 'done' : break
    value = float(inp)
    total = total + value
    count = count + 1

average = total / count
print('Average:', average)
```

```
Enter a number: 3
Enter a number: 9
Enter a number: 5
Enter a number: done
Average: 5.66666666667
```

```
numlist = list()
while True :
    inp = input('Enter a number: ')
    if inp == 'done' : break
    value = float(inp)
    numlist.append(value)

average = sum(numlist) / len(numlist)
print('Average:', average)
```

Best Friends: Strings and Lists

```
>>> abc = 'With three words'
>>> stuff = abc.split()
>>> print(stuff)
['With', 'three', 'words']
>>> print(len(stuff))
3
>>> print(stuff[0])
With
```

```
>>> print(stuff)
['With', 'three', 'words']
>>> for w in stuff :
...     print(w)
...
With
Three
Words
>>>
```

Split breaks a string into parts and produces a list of strings. We think of these as words. We can access a particular word or loop through all the words.

```
>>> line = 'A lot                    of spaces'
>>> etc = line.split()
>>> print(etc)
['A', 'lot', 'of', 'spaces']
>>>
>>> line = 'first;second;third'
>>> thing = line.split()
>>> print(thing)
['first;second;third']
>>> print(len(thing))
1
>>> thing = line.split(';')
>>> print(thing)
['first', 'second', 'third']
>>> print(len(thing))
3
>>>
```

- When you do not specify a delimiter, multiple spaces are treated like one delimiter
- You can specify what delimiter character to use in the splitting

From stephen.marquard@uct.ac.za Sat Jan 5 09:14:16 2008

```
fhand = open('mbox-short.txt')
for line in fhand:
    line = line.rstrip()
    if not line.startswith('From ') : continue
    words = line.split()
    print(words[2])
```

Sat
Fri
Fri
Fri
...

```
>>> line = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
>>> words = line.split()
>>> print(words)
['From', 'stephen.marquard@uct.ac.za', 'Sat', 'Jan', '5', '09:14:16', '2008']
>>>
```

The Double Split Pattern

Sometimes we split a line one way, and then grab one of the pieces of the line and split that piece again

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
words = line.split()
email = words[1]
```

The Double Split Pattern

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
words = line.split()
email = words[1]
```

stephen.marquard@uct.ac.za

The Double Split Pattern

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
words = line.split()
email = words[1]
pieces = email.split('@')
```

```
stephen.marquard@uct.ac.za
['stephen.marquard', 'uct.ac.za']
```

The Double Split Pattern

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
words = line.split()
email = words[1]
pieces = email.split('@')
print(pieces[1])
```

```
stephen.marquard@uct.ac.za
['stephen.marquard', 'uct.ac.za']
'uct.ac.za'
```

List Summary

- Concept of a collection
- Lists and definite loops
- Indexing and lookup
- List mutability
- Functions: len, min, max, sum
- Slicing lists
- List methods: append, remove
- Sorting lists
- Splitting strings into lists of words
- Using split to parse strings

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translators here

...

Python Dictionaries

Chapter 9

Python for Everybody
www.py4e.com

What is a Collection?

- A collection is nice because we can put more than one value in it and carry them all around in one convenient package
- We have a bunch of values in a single “variable”
- We do this by having more than one place “in” the variable
- We have ways of finding the different places in the variable

What is Not a “Collection”?

Most of our variables have one value in them - when we put a new value in the variable - the old value is overwritten

```
$ python
>>> x = 2
>>> x = 4
>>> print(x)
4
```

A Story of Two Collections..

- List

  A linear collection of values
  Lookup by position 0 .. length-1

- Dictionary

  A linear collection of key-value pairs
  Lookup by "tag" or "key"

https://en.wikipedia.org/wiki/Index_card#/media/File:LA2-katalogkort.jpg
https://commons.wikimedia.org/wiki/File:Shelves-of-file-folders.jpg

Dictionaries

- Dictionaries are Python’s most powerful data collection
- Dictionaries allow us to do fast database-like operations in Python
- Similar concepts in different programming languages
  - Associative Arrays - Perl / PHP
  - Properties or Map or HashMap - Java
  - Property Bag - C# / .Net

Dictionaries over time in Python

- Prior to Python 3.7 dictionaries did not keep entries in the order of insertion
- Python 3.7 (2018) and later dictionaries keep entries in the order they were inserted
- "insertion order" is not "always sorted order"

Below the Abstraction

- Python lists, dictionaries, and tuples are "abstract objects" designed to be easy to use
- For now we will just understand them and use them and thank the creators of Python for making them easy for us
- Using Python collections is easy. Creating the code to support them is tricky and uses Computer Science concepts like dynamic memory, arrays, linked lists, hash maps and trees.
- But that implementation detail is for a later course…

Lists (Review)

- We append values to the end of a List and look them up by position
- We insert values into a Dictionary using a key and retrieve them using a key

```
>>> cards = list()
>>> cards.append(12)
>>> cards.append(3)
>>> cards.append(75)
>>> print(cards)
[12, 3, 75]
>>> print(cards[1])
3
>>> cards[1] = cards[1] + 2
>>> print(cards)
[12, 5, 75]
```

Dictionaries

- We append values to the end of a List and look them up by position
- We insert values into a Dictionary using a key and retrieve them using a key

```
>>> cabinet = dict()
>>> cabinet['summer'] = 12
>>> cabinet['fall'] = 3
>>> cabinet['spring'] = 75
>>> print(cabinet)
{'summer': 12, fall': 3, spring': 75}
>>> print(cabinet['fall'])
3
>>> cabinet['fall'] = cabinet['fall'] + 2
>>> print(cabinet)
{'summer': 12, 'fall': 5, 'spring': 75}
```

Comparing Lists and Dictionaries

Dictionaries are like lists except that they use keys instead of positions to look up values

```
>>> lst = list()
>>> lst.append(21)
>>> lst.append(183)
>>> print(lst)
[21, 183]
>>> lst[0] = 23
>>> print(lst)
[23, 183]
```

```
>>> ddd = dict()
>>> ddd['age'] = 21
>>> ddd['course'] = 182
>>> print(ddd)
{'age': 21, 'course': 182}
>>> ddd['age'] = 23
>>> print(ddd)
{'age': 23, 'course': 182}
```

Dictionary Literals (Constants)

- Dictionary literals use curly braces and have key : value pairs
- You can make an empty dictionary using empty curly braces

```
>>> jjj = { 'chuck' : 1 , 'fred' : 42, 'jan': 100}
>>> print(jjj)
{'chuck': 1, 'fred': 42, 'jan': 100}
>>> ooo = { }
>>> print(ooo)
{}
>>>
```

Most Common Name?

Most Common Name?

marquard

zhen

csev

zhen

cwen

marquard

zhen

csev

cwen

zhen

csev

marquard

zhen

Most Common Name?

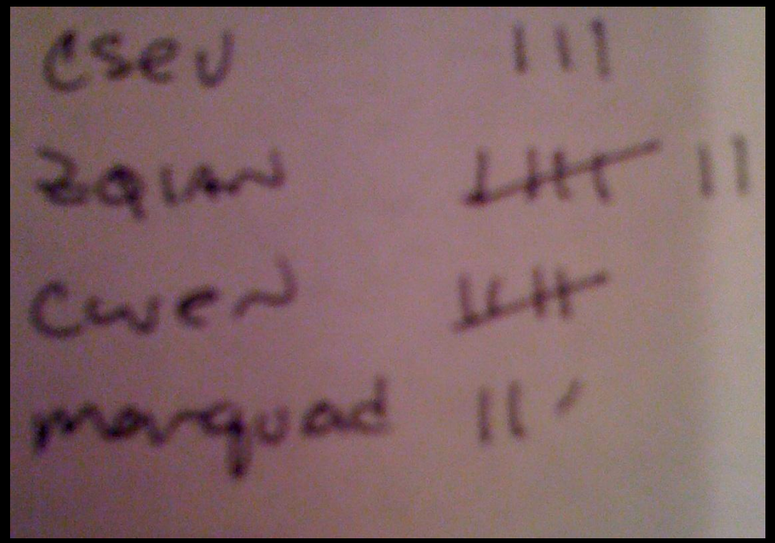
marquard

zhen

csev

zhen

cwen



csev

cwen

zhen

csev

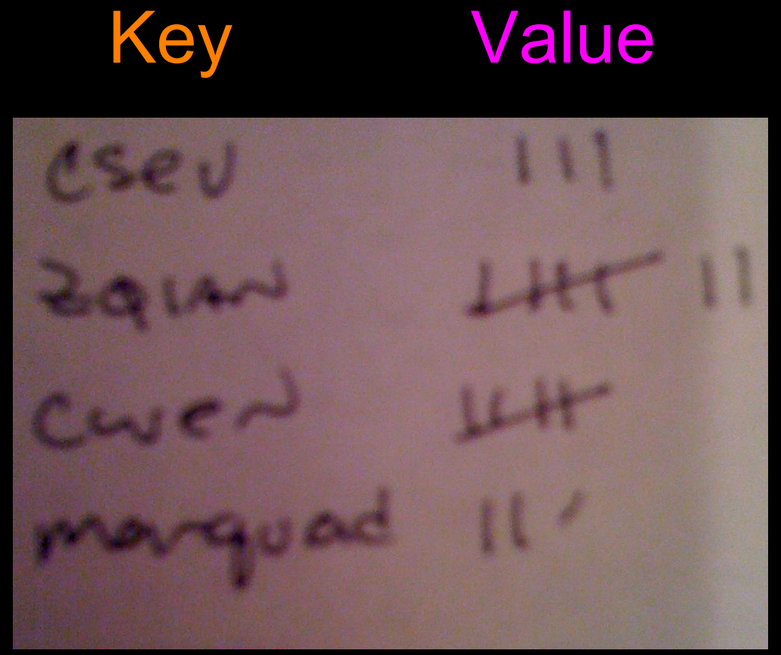
marquard

zhen

Many Counters with a Dictionary

One common use of dictionaries is counting how often we “see” something

```
>>> ccc = dict()
>>> ccc['csev'] = 1
>>> ccc['cwen'] = 1
>>> print(ccc)
{'csev': 1, 'cwen': 1}
>>> ccc['cwen'] = ccc['cwen'] + 1
>>> print(ccc)
{'csev': 1, 'cwen': 2}
```



Dictionary Tracebacks

- It is an error to reference a key which is not in the dictionary
- We can use the in operator to see if a key is in the dictionary

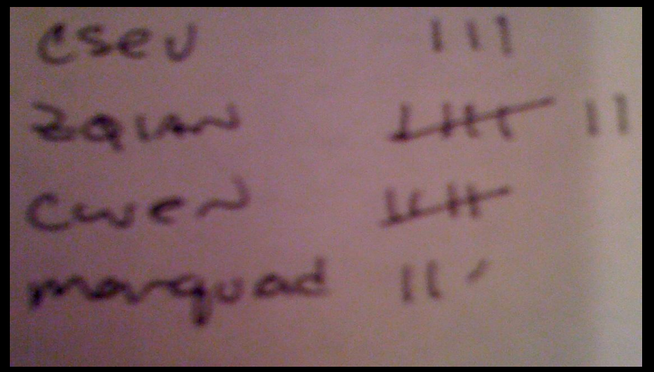
```
>>> ccc = dict()
>>> print(ccc['csev'])
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'csev'
>>> 'csev' in ccc
False
```

When We See a New Name

When we encounter a new name, we need to add a new entry in the dictionary and if this the second or later time we have seen the name, we simply add one to the count in the dictionary under that name

```
counts = dict()
names = ['csev', 'cwen', 'csev', 'zqian', 'cwen']
for name in names :
    if name not in counts:
       counts[name] = 1
    else :
        counts[name] = counts[name] + 1
print(counts)
```

{'csev': 2, 'cwen': 2 , 'zqian': 1}



The get Method for Dictionaries

The pattern of checking to see if a key is already in a dictionary and assuming a default value if the key is not there is so common that there is a method called get() that does this for us

```
if name in counts:
    x = counts[name]
else :
    x = 0
```

```
x = counts.get(name, 0)
```

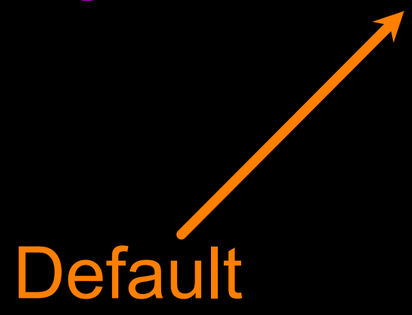
Default value if key does not exist (and no Traceback).

{'csev': 2, 'cwen': 2 , 'zqian': 1}

Simplified Counting with get()

We can use get() and provide a default value of zero when the key is not yet in the dictionary - and then just add one

```
counts = dict()
names = ['csev', 'cwen', 'csev', 'zqian', 'cwen']
for name in names :
    counts[name] = counts.get(name, 0) + 1
print(counts)
```



{'csev': 2, 'cwen': 2 , 'zqian': 1}

Counting Words in Text

Writing programs (or programming) is a very creative and rewarding activity. You can write programs for many reasons ranging from making your living to solving a difficult data analysis problem to having fun to helping someone else solve a problem. This book assumes that everyone needs to know how to program and that once you know how to program, you will figure out what you want to do with your newfound skills.

We are surrounded in our daily lives with computers ranging from laptops to cell phones. We can think of these computers as our "personal assistants" who can take care of many things on our behalf. The hardware in our current-day computers is essentially built to continuously ask us the question, "What would you like me to do next?"

Our computers are fast and have vast amounts of memory and could be very helpful to us if we only knew the language to speak to explain to the computer what we would like it to do next. If we knew this language we could tell the computer to do tasks on our behalf that were repetitive. Interestingly, the kinds of things computers can do best are often the kinds of things that we humans find boring and mind-numbing.

Counting Pattern

```
counts = dict()
print('Enter a line of text:')
line = input('')

words = line.split()

print('Words:', words)

print('Counting...')
for word in words:
    counts[word] = counts.get(word,0) + 1
print('Counts', counts)
```

The general pattern to count the words in a line of text is to split the line into words, then loop through the words and use a dictionary to track the count of each word independently.

```
python wordcount.py
Enter a line of text:
the clown ran after the car and the car ran into the tent
and the tent fell down on the clown and the car

Words: ['the', 'clown', 'ran', 'after', 'the', 'car',
'and', 'the', 'car', 'ran', 'into', 'the', 'tent', 'and',
'the', 'tent', 'fell', 'down', 'on', 'the', 'clown',
'and', 'the', 'car']
Counting…

Counts {'the': 7, 'clown': 2, 'ran': 2, 'after': 1, 'car':
3, 'and': 3, 'into': 1, 'tent': 2, 'fell': 1, 'down': 1,
'on': 1}
```

```
counts = dict()
line = input('Enter a line of text:')
words = line.split()

print('Words:', words)
print('Counting...’)

for word in words:
    counts[word] = counts.get(word,0) + 1
print('Counts', counts)
```

```
python wordcount.py
Enter a line of text:
the clown ran after the car and the car ran into the tent and the tent fell down on the clown and the car

Words: ['the', 'clown', 'ran', 'after', 'the', 'car', 'and', 'the', 'car', 'ran', 'into', 'the', 'tent', 'and', 'the', 'tent', 'fell', 'down', 'on', 'the', 'clown', 'and', 'the', 'car']
Counting...

Counts {'the': 7, 'clown': 2, 'ran': 2, 'after': 1, 'car': 3, 'and': 3, 'into': 1, 'tent': 2, 'fell': 1, 'down': 1, 'on': 1}
```

Definite Loops and Dictionaries

We can write a for loop that goes through all the entries in a dictionary - actually it goes through all of the keys in the dictionary and looks up the values

```
>>> counts = { 'chuck' : 1 , 'fred' : 42, 'jan': 100}
>>> for key in counts:
...     print(key, counts[key])
...
chuck 1
fred 42
jan 100
>>>
```

Retrieving Lists of Keys and Values

You can get a list of keys, values, or items (both) from a dictionary

```
>>> jjj = { 'chuck' : 1 , 'fred' : 42, 'jan': 100}
>>> print(list(jjj))
['chuck', 'fred', 'jan']
>>> print(list(jjj.keys()))
['chuck', 'fred', 'jan']
>>> print(list(jjj.values()))
[1, 42, 100]
>>> print(list(jjj.items()))
[('chuck', 1), ('fred', 42), ('jan', 100)]
>>>
```

What is a “tuple”? - coming soon...

Bonus: Two Iteration Variables!

- We loop through the key-value pairs in a dictionary using *two* iteration variables
- Each iteration, the first variable is the key and the second variable is the corresponding value for the key

```
jjj = { 'chuck' : 1 , 'fred' : 42, 'jan': 100}
for aaa,bbb in jjj.items() :
    print(aaa, bbb)
```

```
chuck 1
fred 42
jan 100
```

aaa	bbb
[chuck]	1
[fred]	42
[jan]	100

```
name = input('Enter file:')
handle = open(name)

counts = dict()
for line in handle:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word,0) + 1

bigcount = None
bigword = None
for word,count in counts.items():
    if bigcount is None or count > bigcount:
        bigword = word
        bigcount = count

print(bigword, bigcount)
```

```
python words.py
Enter file: words.txt
to 16
```

```
python words.py
Enter file: clown.txt
the 7
```

Using two nested loops

Summary

- What is a collection
- Lists versus dictionaries
- Dictionary Constants
- The most common word
- Using the get() method
- Writing dictionary loops
- Sneak peek: Tuples

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

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Tuples

Chapter 10

Python for Everybody

www.py4e.com

Tuples Are Like Lists

Tuples are another kind of sequence that functions much like a list - they have elements which are indexed starting at 0

```
>>> x = ('Glenn', 'Sally', 'Joseph')
>>> print(x[2])
Joseph
>>> y = ( 1, 9, 2 )
>>> print(y)
(1, 9, 2)
>>> print(max(y))
9
```

```
>>> for iter in y:
...     print(iter)
...
1
9
2
>>>
```

but... Tuples are “immutable”

Unlike a list, once you create a tuple, you cannot alter its contents - similar to a string

```
>>> x = [9, 8, 7]
>>> x[2] = 6
>>> print(x)
>>>[9, 8, 6]
>>>
```

```
>>> y = 'ABC'
>>> y[2] = 'D'
Traceback:'str'
object does
not support item
Assignment
>>>
```

```
>>> z = (5, 4, 3)
>>> z[2] = 0
Traceback:'tuple'
object does
not support item
Assignment
>>>
```

Things not to do With Tuples

```
>>> x = (3, 2, 1)
>>> x.sort()
Traceback:
AttributeError: 'tuple' object has no attribute 'sort'
>>> x.append(5)
Traceback:
AttributeError: 'tuple' object has no attribute 'append'
>>> x.reverse()
Traceback:
AttributeError: 'tuple' object has no attribute 'reverse'
>>>
```

A Tale of Two Sequences

```
>>> l = list()
>>> dir(l)
['append', 'count', 'extend', 'index', 'insert', 'pop',
'remove', 'reverse', 'sort']

>>> t = tuple()
>>> dir(t)
['count', 'index']
```

Tuples are More Efficient

- Since Python does not have to build tuple structures to be modifiable, they are simpler and more efficient in terms of memory use and performance than lists
- So in our program when we are making “temporary variables” we prefer tuples over lists

Tuples and Assignment

- We can also put a tuple on the left-hand side of an assignment statement
- We can even omit the parentheses

```
>>> (x, y) = (4, 'fred')
>>> print(y)
fred
>>> (a, b) = (99, 98)
>>> print(a)
99
```

Tuples and Dictionaries

The items() method in dictionaries returns a list of (key, value) tuples

```
>>> d = dict()
>>> d['csev'] = 2
>>> d['cwen'] = 4
>>> for (k,v) in d.items():
...     print(k, v)
...
csev 2
cwen 4
>>> tups = d.items()
>>> print(tups)
dict_items([('csev', 2), ('cwen', 4)])
```

Tuples are Comparable

The comparison operators work with tuples and other sequences. If the first item is equal, Python goes on to the next element, and so on, until it finds elements that differ.

```
>>> (0, 1, 2) < (5, 1, 2)
True
>>> (0, 1, 2000000) < (0, 3, 4)
True
>>> ( 'Jones', 'Sally' ) < ('Jones', 'Sam')
True
>>> ( 'Jones', 'Sally') > ('Adams', 'Sam')
True
```

Sorting Lists of Tuples

- We can take advantage of the ability to sort a list of tuples to get a sorted version of a dictionary
- First we sort the dictionary by the key using the items() method and sorted() function

```
>>> d = {'a':10, 'c':22, 'b':1}
>>> d.items()
dict_items([('a', 10), ('c', 22), ('b', 1)])
>>> sorted(d.items())
[('a', 10), ('b', 1), ('c', 22)]
```

Using sorted()

We can do this even more directly using the built-in function sorted that takes a sequence as a parameter and returns a sorted sequence

```
>>> d = {'a':10 , 'b':1, 'c':22}
>>> t = sorted(d.items())
>>> t
[('a', 10), ('b', 1), ('c', 22)]
>>> for k, v in sorted(d.items()):
...     print(k, v)
...
a 10
b 1
c 22
```

Sort by Values Instead of Key

- If we could construct a list of tuples of the form (value, key) we could sort by value
- We do this with a for loop that creates a list of tuples

```
>>> c = {'a':10, 'b':1, 'c':22}
>>> tmp = list()
>>> for k, v in c.items() :
...       tmp.append( (v, k) )
...
>>> print(tmp)
[(10, 'a') , (1, 'b'), (22, 'c')]
>>> tmp = sorted(tmp, reverse=True)
>>> print(tmp)
[(22, 'c'), (10, 'a'), (1, 'b')]
```

The top 10 most common words

```
fhand = open('romeo.txt')
counts = {}
for line in fhand:
    words = line.split()
    for word in words:
        counts[word] = counts.get(word, 0 ) + 1

lst = []
for key, val in counts.items():
    newtup = (val, key)
    lst.append(newtup)

lst = sorted(lst, reverse=True)

for val, key in lst[:10] :
    print(key, val)
```

Even Shorter Version

```
>>> c = {'a':10, 'b':1, 'c':22}

>>> print( sorted( [ (v,k) for k,v in c.items() ] ) )

[(1, 'b'), (10, 'a'), (22, 'c')]
```

List comprehension creates a dynamic list. In this case, we make a list of reversed tuples and then sort it.

http://wiki.python.org/moin/HowTo/Sorting

Summary

- Tuple syntax
- Immutability
- Comparability
- Sorting

- Tuples in assignment statements
- Sorting dictionaries by either key or value

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

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Regular Expressions

Chapter 11

Python for Everybody
www.py4e.com

Regular Expressions

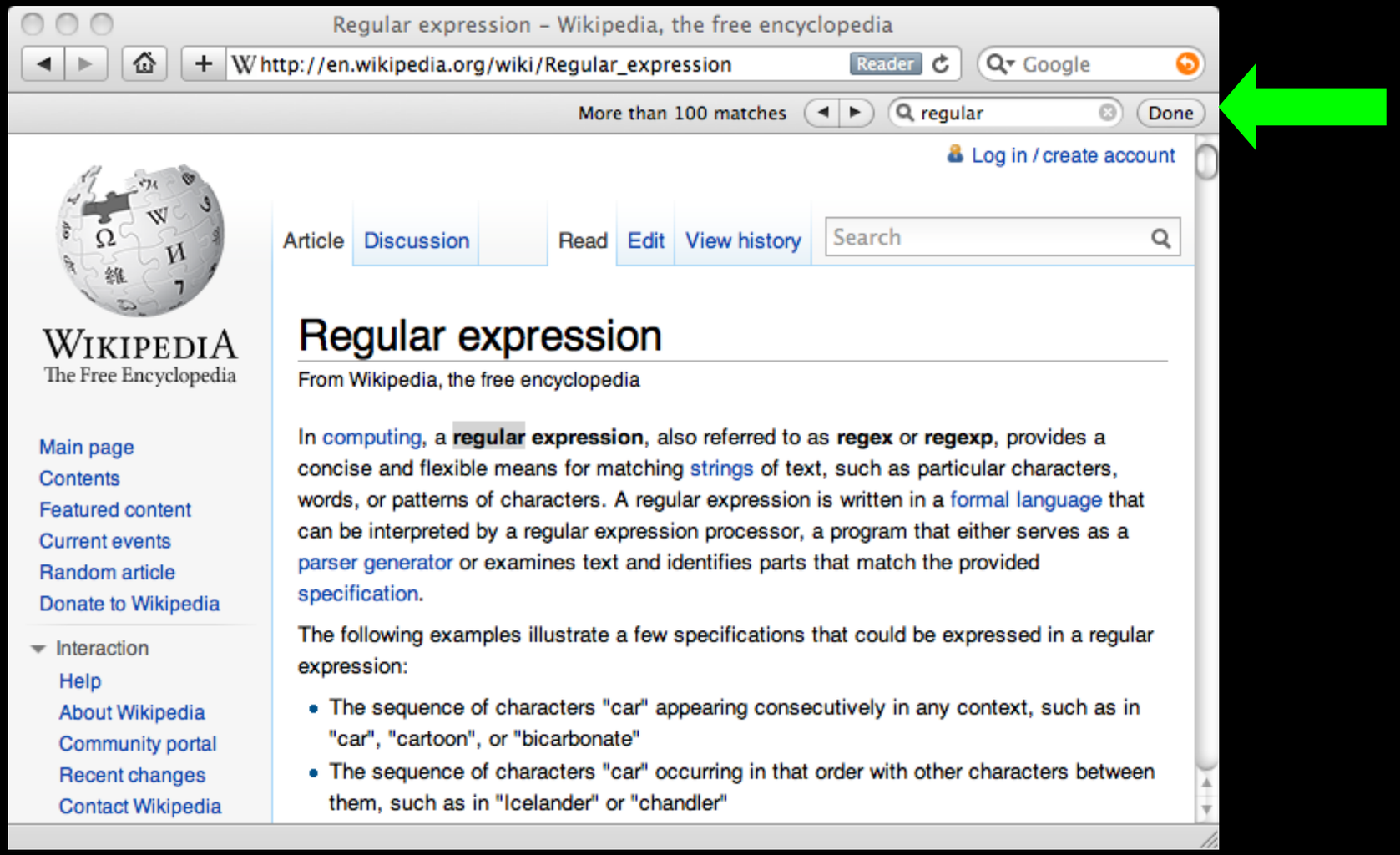
In computing, a regular expression, also referred to as “regex” or “regexp”, provides a concise and flexible means for matching strings of text, such as particular characters, words, or patterns of characters. A regular expression is written in a formal language that can be interpreted by a regular expression processor.

http://en.wikipedia.org/wiki/Regular_expression

Regular Expressions

Really clever “wild card” expressions for matching and parsing strings

http://en.wikipedia.org/wiki/Regular_expression


Regular expression – Wikipedia, the free encyclopedia
http://en.wikipedia.org/wiki/Regular_expression
Reader
Google
More than 100 matches
regular
Done
Log in / create account
Article
Discussion
Read
Edit
View history
Search
WIKIPEDIA
The Free Encyclopedia
Main page
Contents
Featured content
Current events
Random article
Donate to Wikipedia
Interaction
Help
About Wikipedia
Community portal
Recent changes
Contact Wikipedia
Regular expression
From Wikipedia, the free encyclopedia
In computing, a regular expression, also referred to as regex or regexp, provides a concise and flexible means for matching strings of text, such as particular characters, words, or patterns of characters. A regular expression is written in a formal language that can be interpreted by a regular expression processor, a program that either serves as a parser generator or examines text and identifies parts that match the provided specification.
The following examples illustrate a few specifications that could be expressed in a regular expression:
The sequence of characters "car" appearing consecutively in any context, such as in "car", "cartoon", or "bicarbonate"
The sequence of characters "car" occurring in that order with other characters between them, such as in "Icelander" or "chandler"

Really smart “Find” or “Search”

Understanding Regular Expressions

- Very powerful and quite cryptic
- Fun once you understand them
- Regular expressions are a language unto themselves
- A language of “marker characters” - programming with characters
- It is kind of an “old school” language - compact

WHENEVER I LEARN A NEW SKILL I CONCOCT ELABORATE FANTASY SCENARIOS WHERE IT LETS ME SAVE THE DAY.
OH NO! THE KILLER MUST HAVE FOLLOWED HER ON VACATION!
BUT TO FIND THEM WE'D HAVE TO SEARCH THROUGH 200 MB OF EMAILS LOOKING FOR SOMETHING FORMATTED LIKE AN ADDRESS!
IT'S HOPELESS!
EVERYBODY STAND BACK.
I KNOW REGULAR EXPRESSIONS.
PERL!
TAP TAP

http://xkcd.com/208/

Regular Expression Quick Guide

```
^          Matches the beginning of a line
$          Matches the end of the line
.          Matches any character
\s         Matches whitespace
\S         Matches any non-whitespace character
*          Repeats a character zero or more times
*?         Repeats a character zero or more times (non-greedy)
+          Repeats a character one or more times
+?         Repeats a character one or more times (non-greedy)
[aeiou]    Matches a single character in the listed set
[^XYZ]     Matches a single character not in the listed set
[a-z0-9]   The set of characters can include a range
(          Indicates where string extraction is to start
)          Indicates where string extraction is to end
```

https://www.py4e.com/lectures3/Pythonlearn-11-Regex-Handout.txt

The Regular Expression Module

- Before you can use regular expressions in your program, you must import the library using “import re”
- You can use re.search() to see if a string matches a regular expression, similar to using the find() method for strings
- You can use re.findall() to extract portions of a string that match your regular expression, similar to a combination of find() and slicing: var[5:10]

Using re.search() Like find()

```
hand = open('mbox-short.txt')
for line in hand:
    line = line.rstrip()
    if line.find('From:') >= 0:
        print(line)
```

```
import re

hand = open('mbox-short.txt')
for line in hand:
    line = line.rstrip()
    if re.search('From:', line) :
        print(line)
```

Using re.search() Like startswith()

```
hand = open('mbox-short.txt')
for line in hand:
    line = line.rstrip()
    if line.startswith('From:') :
        print(line)
```

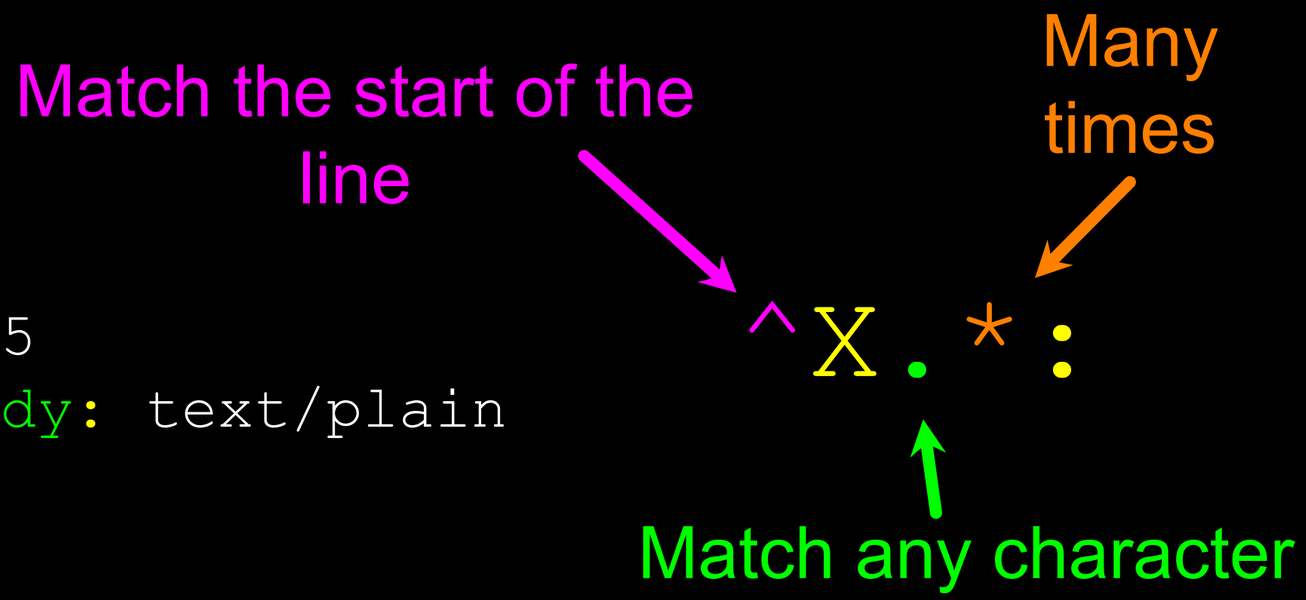
```
import re

hand = open('mbox-short.txt')
for line in hand:
    line = line.rstrip()
    if re.search('^From:', line) :
        print(line)
```

We fine-tune what is matched by adding special characters to the string

Wild-Card Characters

- The dot character matches any character
- If you add the asterisk character, the character is “any number of times”

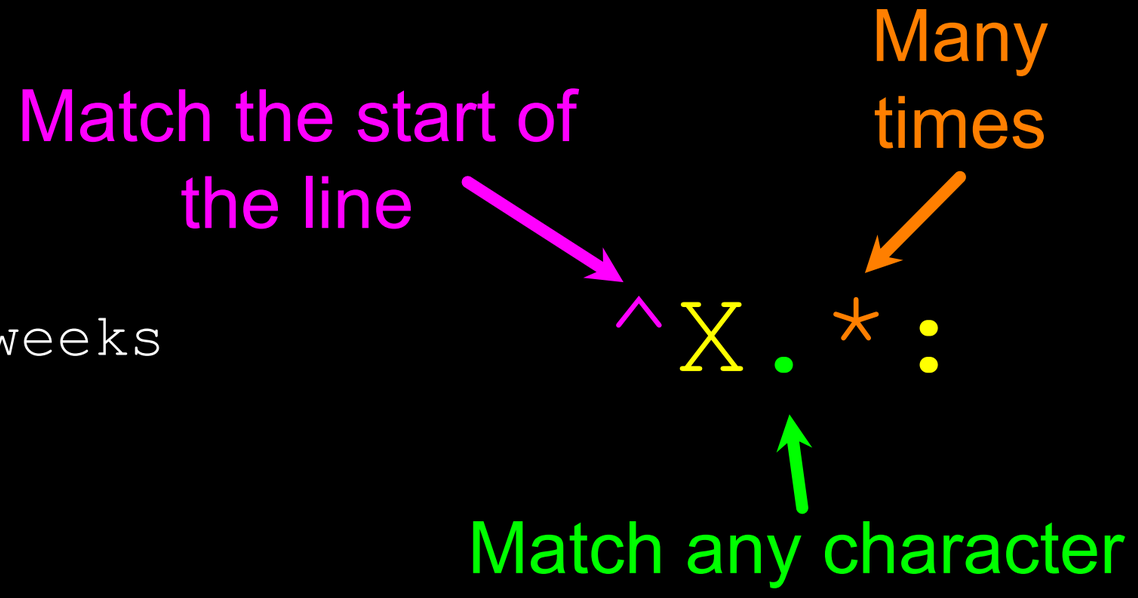
```
X-Sieve: CMU Sieve 2.3
X-DSPAM-Result: Innocent
X-DSPAM-Confidence: 0.8475
X-Content-Type-Message-Body: text/plain
```



Fine-Tuning Your Match

Depending on how “clean” your data is and the purpose of your application, you may want to narrow your match down a bit

```
X-Sieve: CMU Sieve 2.3
X-DSPAM-Result: Innocent
X-Plane is behind schedule: two weeks
X-: Very short
```



Fine-Tuning Your Match

Depending on how “clean” your data is and the purpose of your application, you may want to narrow your match down a bit

```
X-Sieve: CMU Sieve 2.3
X-DSPAM-Result: Innocent
X-: Very Short
X-Plane is behind schedule: two weeks
```

Match the start of the line

One or more times

```
^X-\S+:
```

Match any non-whitespace character

Matching and Extracting Data

- re.search() returns a True/False depending on whether the string matches the regular expression
- If we actually want the matching strings to be extracted, we use re.findall()

```
[0-9]+
```

One or more digits

```
>>> import re
>>> x = 'My 2 favorite numbers are 19 and 42'
>>> y = re.findall('[0-9]+',x)
>>> print(y)
['2', '19', '42']
```

Matching and Extracting Data

When we use re.findall(), it returns a list of zero or more sub-strings that match the regular expression

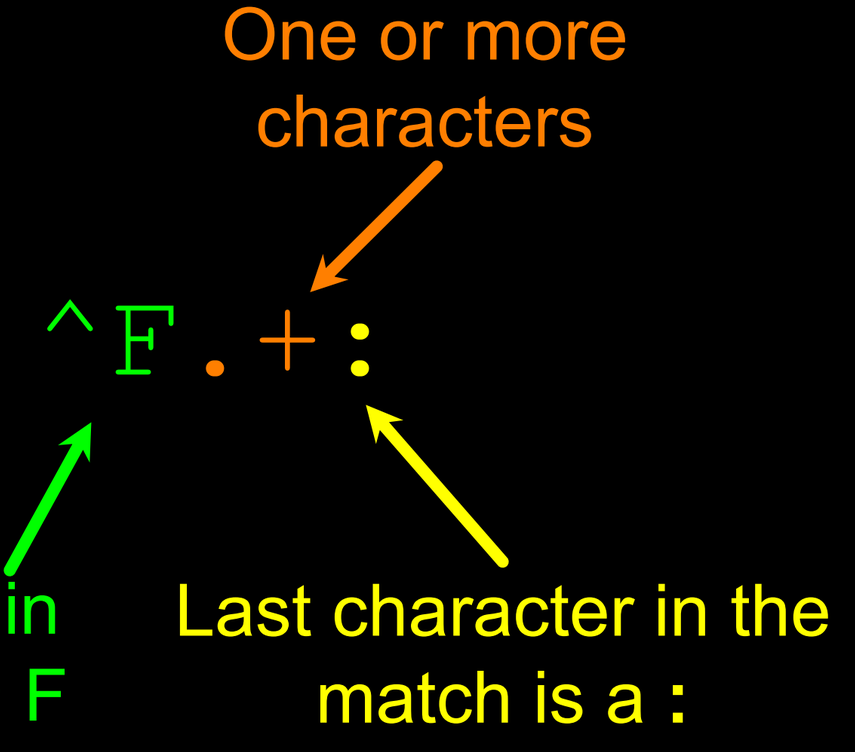
```
>>> import re
>>> x = 'My 2 favorite numbers are 19 and 42'
>>> y = re.findall('[0-9]+',x)
>>> print(y)
['2', '19', '42']
>>> y = re.findall('[AEIOU]+',x)
>>> print(y)
[]
```

Warning: Greedy Matching

The repeat characters (* and +) push outward in both directions (greedy) to match the largest possible string

```
>>> import re
>>> x = 'From: Using the : character'
>>> y = re.findall('^F.+:', x)
>>> print(y)
['From: Using the :']
```

Why not 'From:' ?



Non-Greedy Matching

Not all regular expression repeat codes are greedy!
If you add a ? character, the + and * chill out a bit...

```
>>> import re
>>> x = 'From: Using the : character'
>>> y = re.findall('^F.+?:', x)
>>> print(y)
['From:']
```

One or more characters but not greedy

^F.+?:

First character in the match is an F

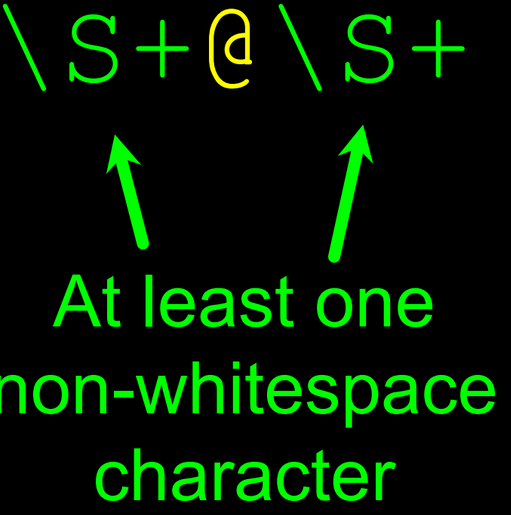
Last character in the match is a :

Fine-Tuning String Extraction

You can refine the match for re.findall() and separately determine which portion of the match is to be extracted by using parentheses

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
>>> y = re.findall('\S+@\S+',x)
>>> print(y)
['stephen.marquard@uct.ac.za']
```



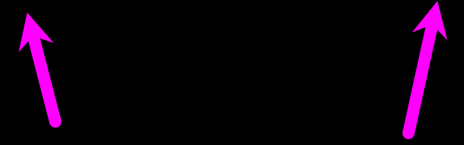
Fine-Tuning String Extraction

Parentheses are not part of the match - but they tell where to start and stop what string to extract

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
>>> y = re.findall('\S+@\S+',x)
>>> print(y)
['stephen.marquard@uct.ac.za']
>>> y = re.findall('^From (\S+@\S+)',x)
>>> print(y)
['stephen.marquard@uct.ac.za']
```

```
^From (\S+@\S+)
```



String Parsing Examples…

```
>>> data = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
>>> atpos = data.find('@')
>>> print(atpos)
21
>>> sppos = data.find(' ',atpos)
>>> print(sppos)
31
>>> host = data[atpos+1 : sppos]
>>> print(host)
uct.ac.za
```

Extracting a host name - using find and string slicing

The Double Split Pattern

Sometimes we split a line one way, and then grab one of the pieces of the line and split that piece again

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
words = line.split()
email = words[1]
pieces = email.split('@')
print(pieces[1])
```

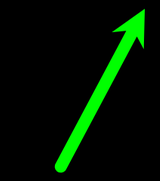
```
stephen.marquard@uct.ac.za
['stephen.marquard', 'uct.ac.za']
'uct.ac.za'
```

The Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('@([^ ]*)',lin)
print(y)

['uct.ac.za']
```

```
'@([^ ]*)'
```

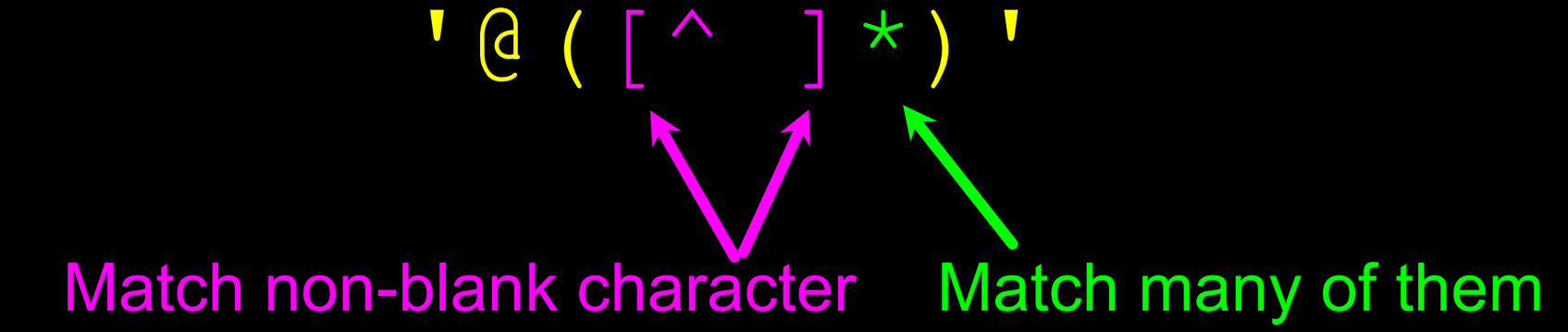


Look through the string until you find an at sign

The Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

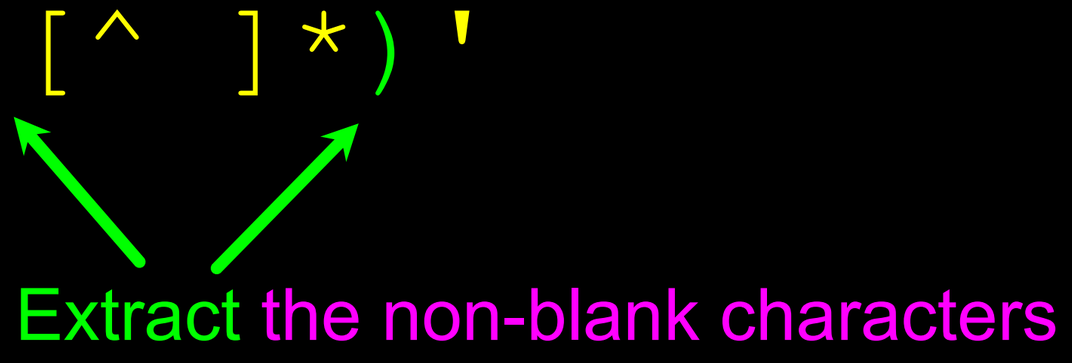
```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('@([^ ]*)',lin)
print(y)

['uct.ac.za']
```



The Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

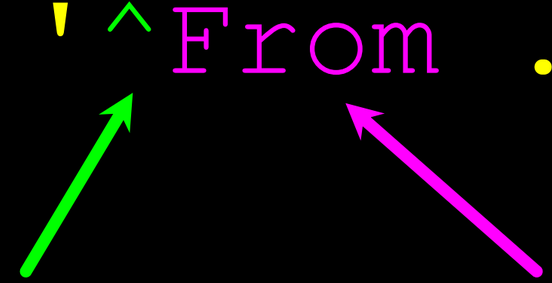
```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('@([^ ]*)',lin)
print(y)

['uct.ac.za']
```



Even Cooler Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

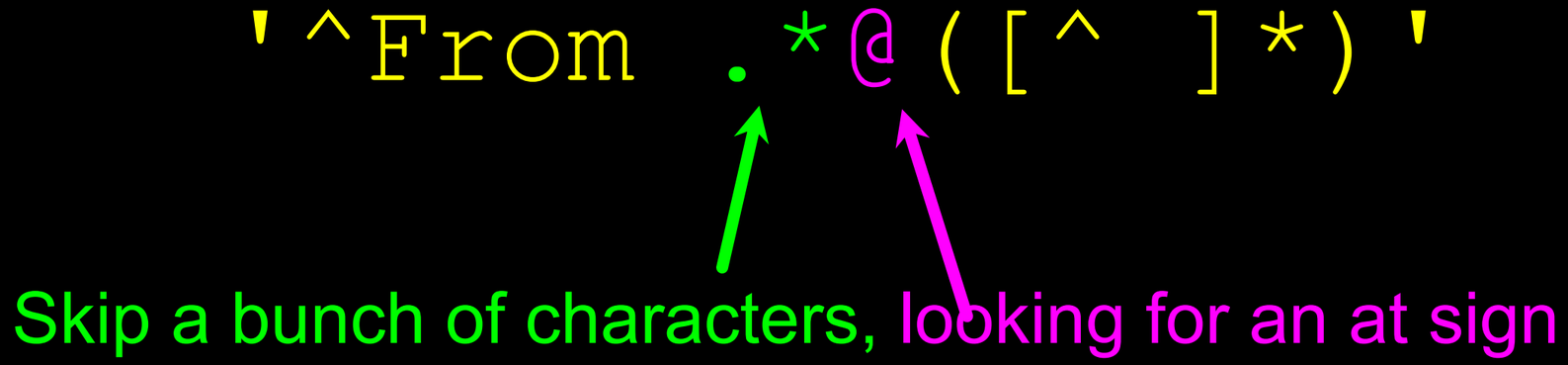
```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('^From .*@([^ ]*)',lin)
print(y)

['uct.ac.za']
```



Even Cooler Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('^From .*@([^ ]*)',lin)
print(y)

['uct.ac.za']
```

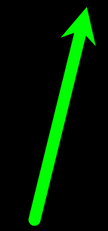


Even Cooler Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('^From .*@([^ ]*)',lin)
print(y)

['uct.ac.za']
```

```
'^From .*@([^ ]*)'
```



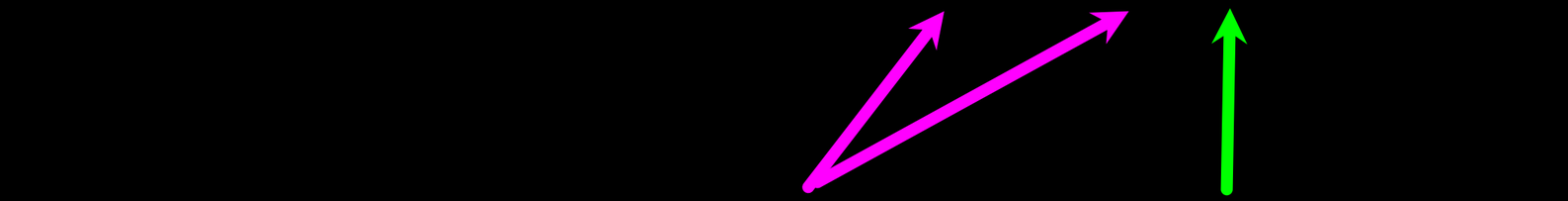
Start extracting

Even Cooler Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('^From .*@([^ ]*)',lin)
print(y)

['uct.ac.za']
```

```
'^From .*@([^ ]+)'
```

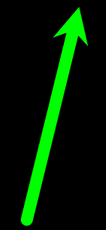


Even Cooler Regex Version

```
From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008
```

```
import re
lin = 'From stephen.marquard@uct.ac.za Sat Jan  5 09:14:16 2008'
y = re.findall('^From .*@([^ ]*)',lin)
print(y)

['uct.ac.za']
```

```
'^From .*@([^ ]+)'
```



Stop extracting

Spam Confidence

```
import re
hand = open('mbox-short.txt')
numlist = list()
for line in hand:
    line = line.rstrip()
    stuff = re.findall('^X-DSPAM-Confidence: ([0-9.]+)', line)
    if len(stuff) != 1 :  continue
    num = float(stuff[0])
    numlist.append(num)
print('Maximum:', max(numlist))
```

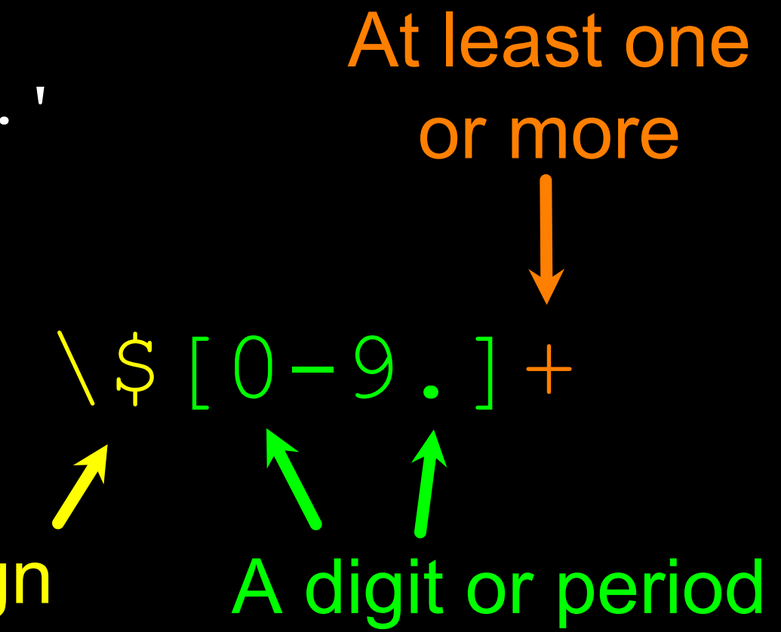
```
X-DSPAM-Confidence: 0.8475
```

```
python ds.py
Maximum: 0.9907
```

Escape Character

If you want a special regular expression character to just behave normally (most of the time) you prefix it with '\'

```
>>> import re
>>> x = 'We just received $10.00 for cookies.'
>>> y = re.findall('\$[0-9.]+',x)
>>> print(y)
['$10.00']
```



Summary

- Regular expressions are a cryptic but powerful language for matching strings and extracting elements from those strings
- Regular expressions have special characters that indicate intent

Acknowledgements / Contributions

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Initial Development: Charles Severance, University of Michigan School of Information

… Insert new Contributors and Translations here

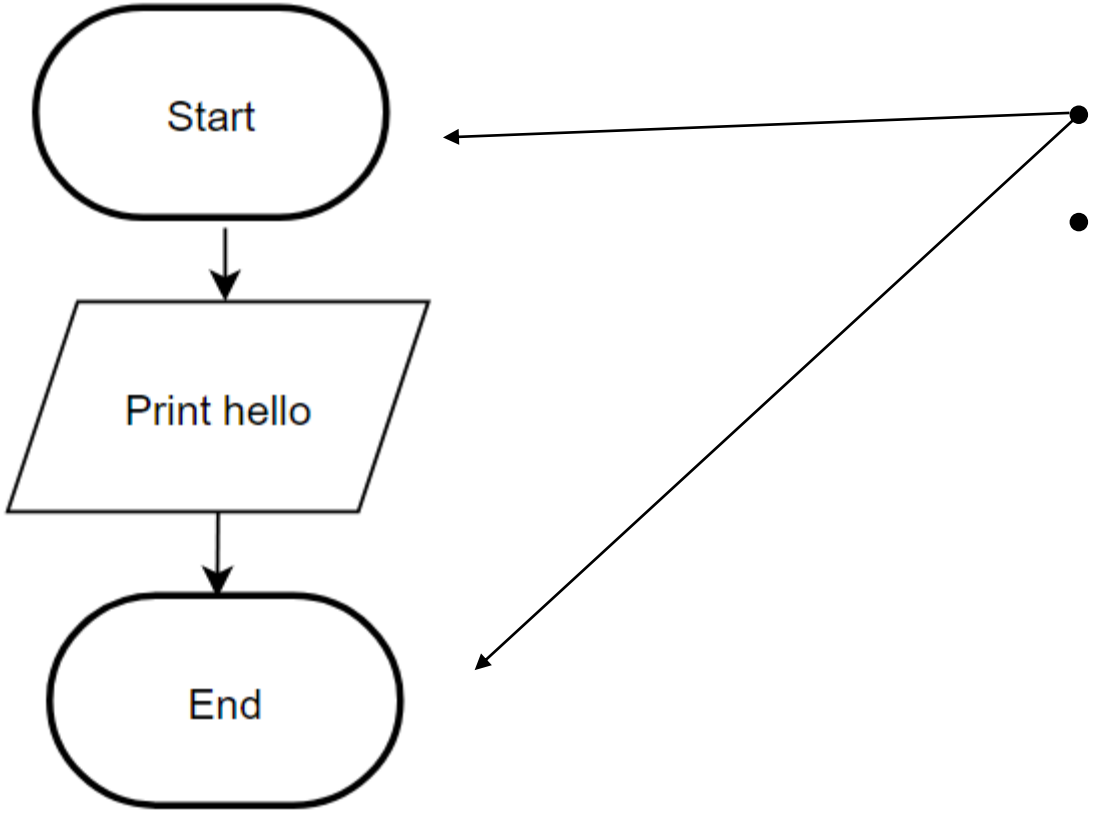
...

Flowcharts

Flowcharts

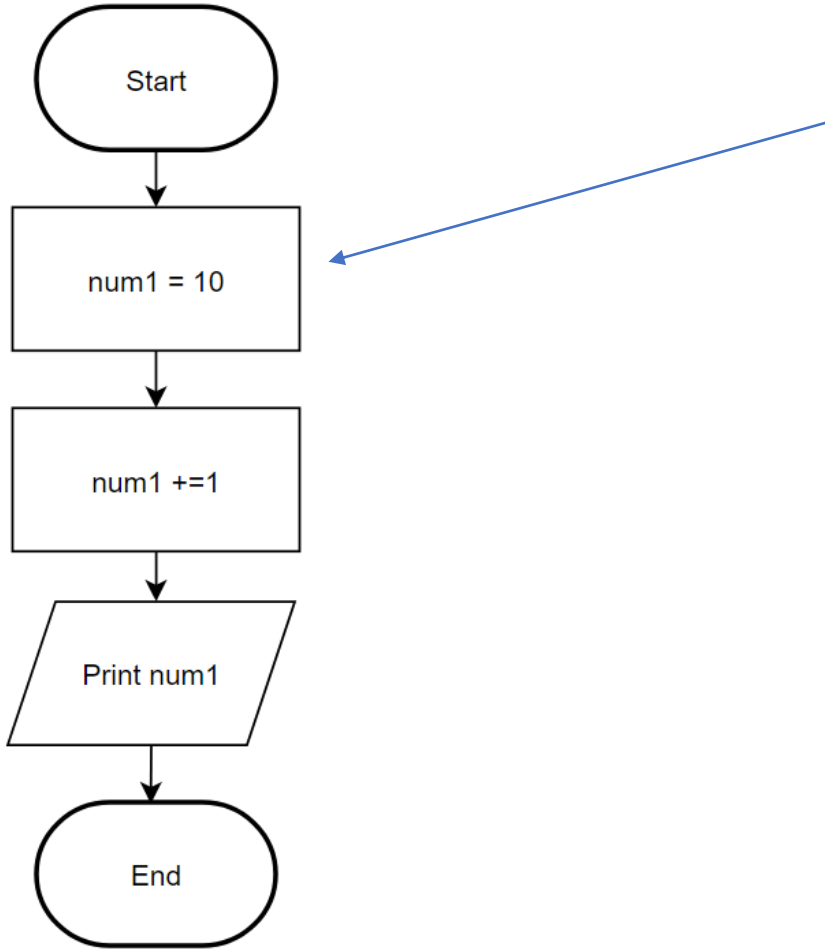
- Flowcharts help us establish the flow of logic in our scripts.
- Creating Flowcharts, like pseudocode will help in planning.
- Flowcharts must be written code agnostic; they are to demonstrate workflow rather than exact code.
- Flowcharts use a syntax of symbols.
- All symbols are connected using arrows to show the direction.

Start/Stop symbol



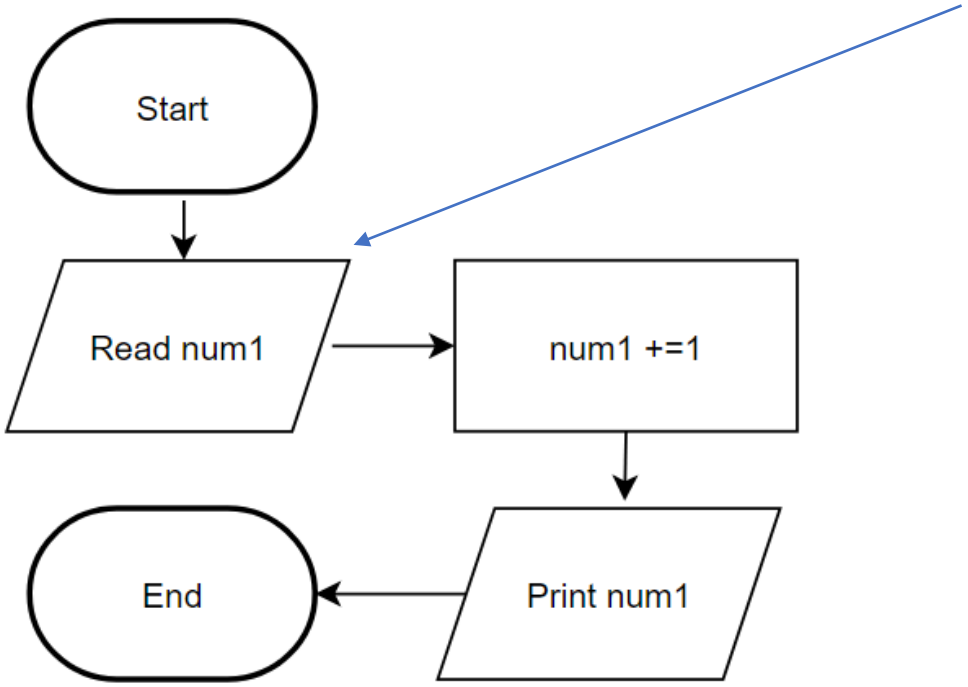
- Oval-ish shape.
- Used to represent the start and end of the script.

Processing symbol



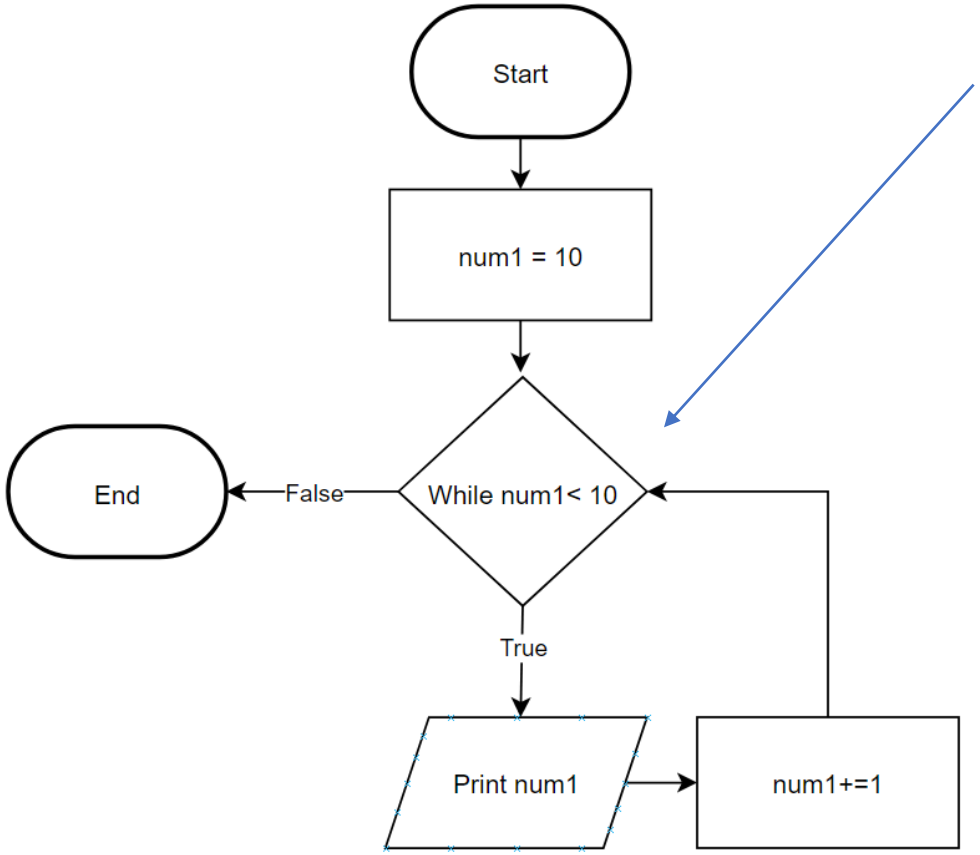
- Rectangle shape.
- Used for processing and other arithmetic operations.
- Generally used with assignment operators.

Input/Output symbol



- Parallelogram
- Used for all input and output operations
- Examples:
  - Input()
  - Print()
  - Writing files
  - Reading files

Decision making symbol



- Diamond.
- Used for any decision-making process
- Includes:
  - if
  - loop
- Should indicate via True/False which step is next.

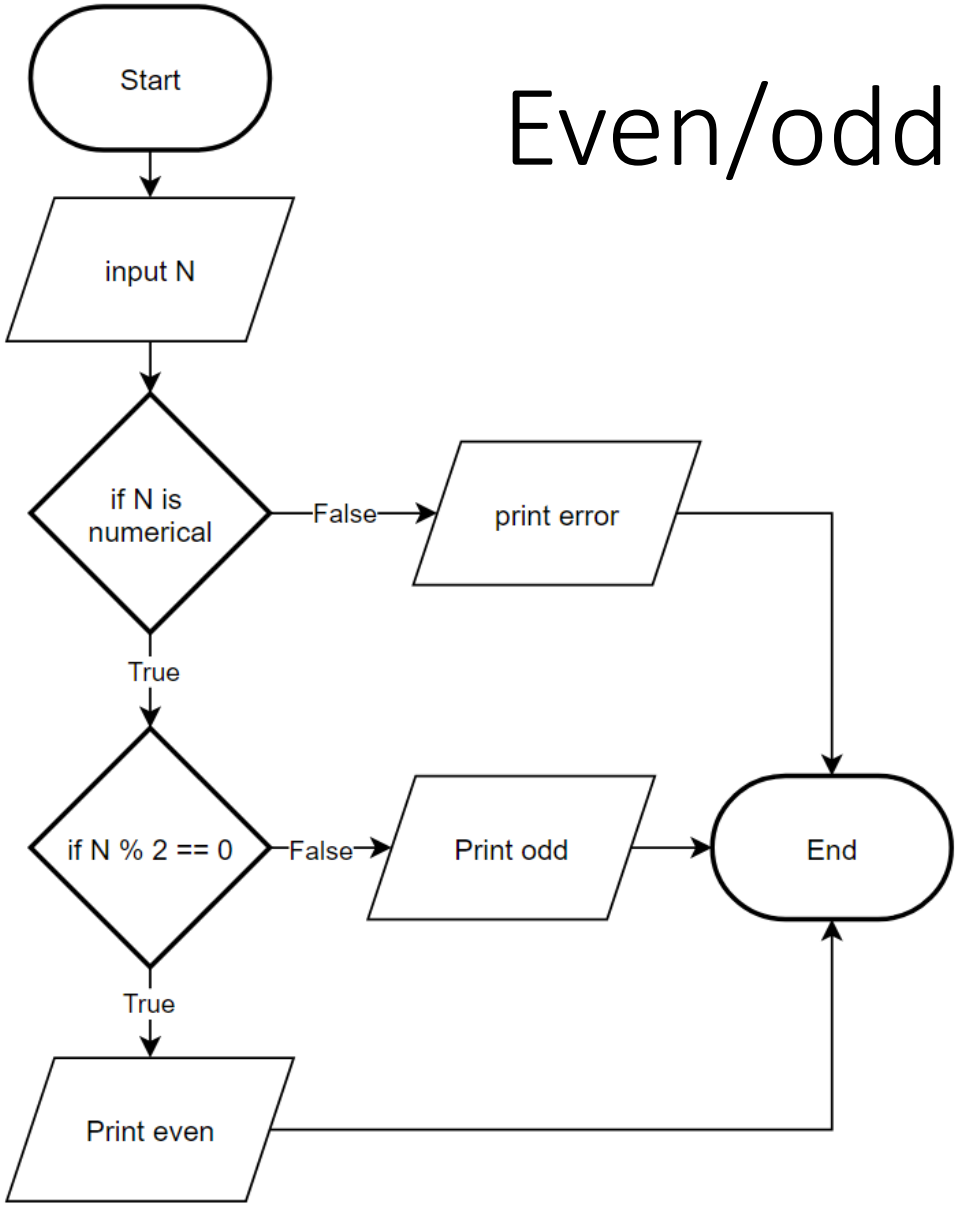
Checking if a number is odd or even

- We want to make a simple script to check if a number is odd or even.
- The script should accept user input of a number and make let the user know if it's odd or even.
- Pseudocode will be provided.
- A flow chart will demonstrate how the script flows visually.
- The code should then be easy to write.

Even/odd pseudocode

- Ask the user for a number (N).
- If N is not numerical
  - print error and close.
- If N divided by 2 remainder is 0
  - print even.
- if N divided by 2 remainder is not 0
  - print odd.

Even/odd flow chart



Even/odd Code

```
# Check if the user's number is even/odd
N = input("Enter a number to check: ")

if N.isnumeric(): # Check if N is a number
    if int(N)%2==0: # Check N divided by 2 remainder is 0
        print("Even!") # Remainder is 0
    else:
        print("Odd!") # Remainder is not 0
else:
    print("not a number")
```

Results

```
========== RESTART: C:/Users/User/De
Enter a number to check: 55
Odd!
>>>
========== RESTART: C:/Users/User/De
Enter a number to check: 56
Even!
>>>
========== RESTART: C:/Users/User/De
Enter a number to check: 4ff
not a number
```

Further info on Flow charts

- https://en.wikipedia.org/wiki/Flowchart
- https://www.lucidchart.com/pages/what-is-a-flowchart-tutorial
- https://creately.com/blog/diagrams/flowchart-guide-flowchart-tutorial/
- https://www.youtube.com/watch?v=xkHWPAHS5c0

Automation

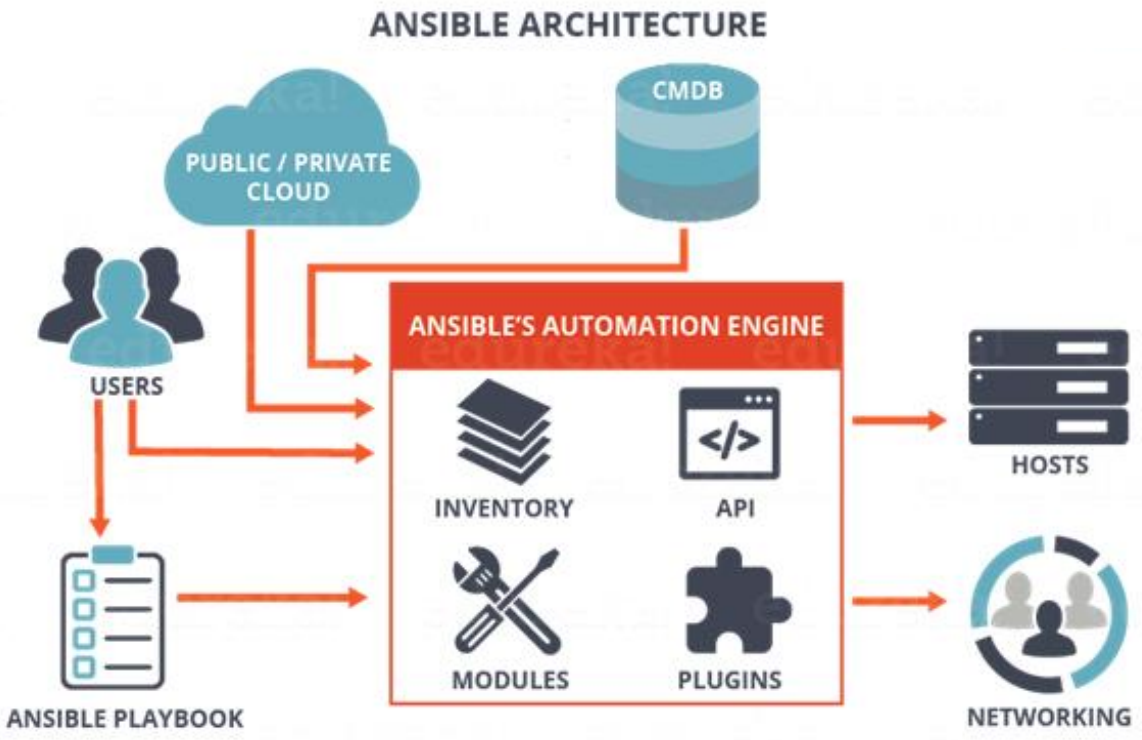
Basic intro to automation

IT vs OT

- IT (Information Technology) focuses on managing and processing digital data, enabling communication, information storage, and software systems.
- OT (Operational Technology) is dedicated to controlling and monitoring physical processes and devices, such as industrial machinery, manufacturing systems, and critical infrastructure.

Automation in IT (example 1)

- Ansible is a command line tool written in **Python**.
- Ansible uses "playbooks" to automate network configuration of servers and other network infrastructure.
- It may assist network engineers automatically deploy, change, update servers, routers, switches, firewalls or any other need on any device.



https://www.ansible.com/overview/how-ansible-works

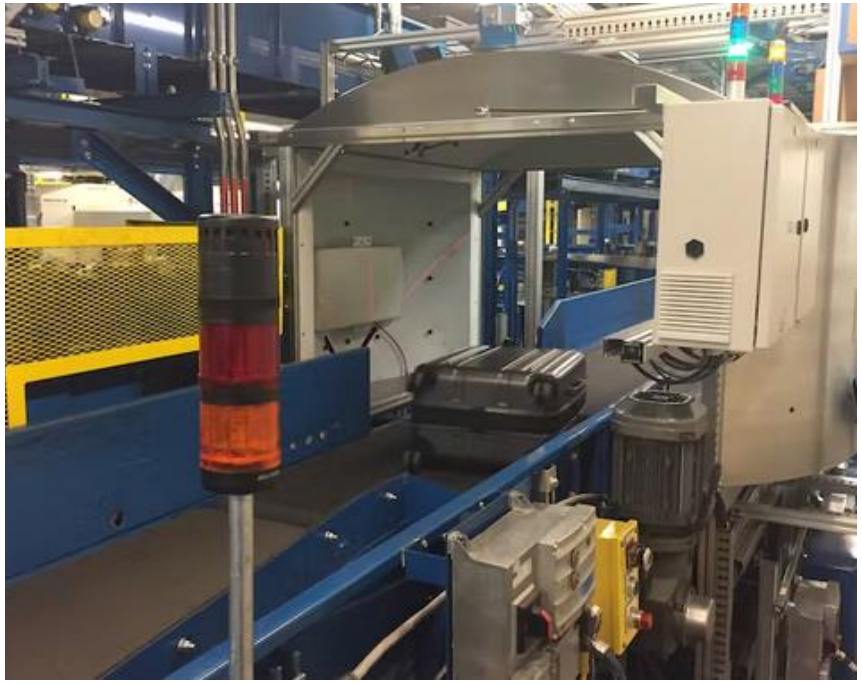
Automation in IT (example 2)

- CI/CD is a type of continuous automated deployment used in software development.
- It helps software developers automatically track, bug check and deploy daily builds of software packages.
- This can be commonly seen in Git pipelines or other tools.

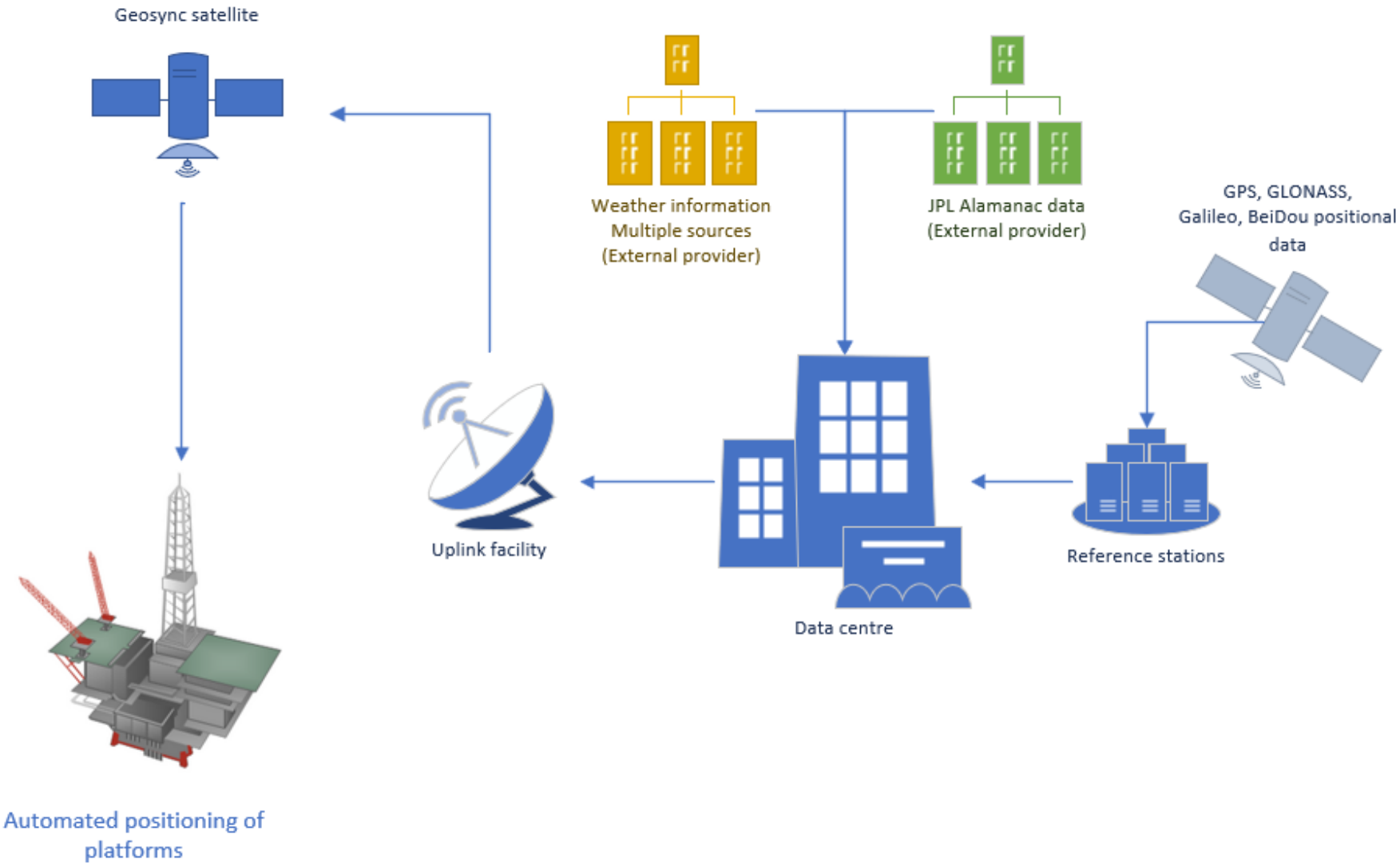
https://www.redhat.com/en/topics/devops/what-is-ci-cd

Automation in OT (example 1)

1. At check in, a barcode is put on the bag.
2. Sensors on conveyor belts will scan for barcodes.
3. Based on the code, the PLC will use motors or other devices to change the conveyor belt the bag is going to.
4. That conveyor belt will go to the gate the plane is loading at.

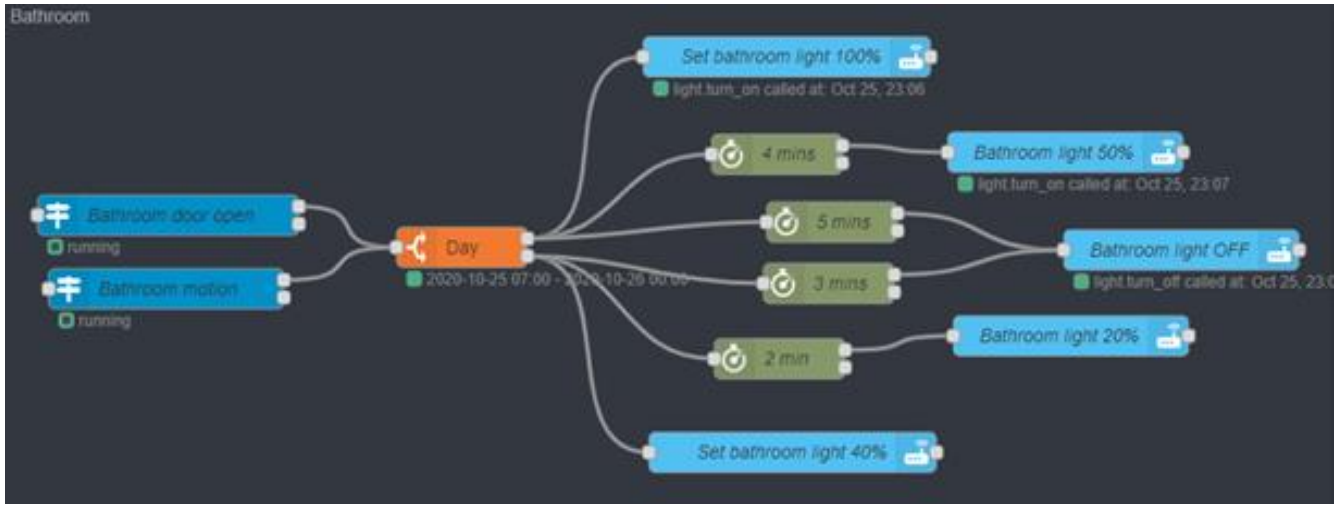


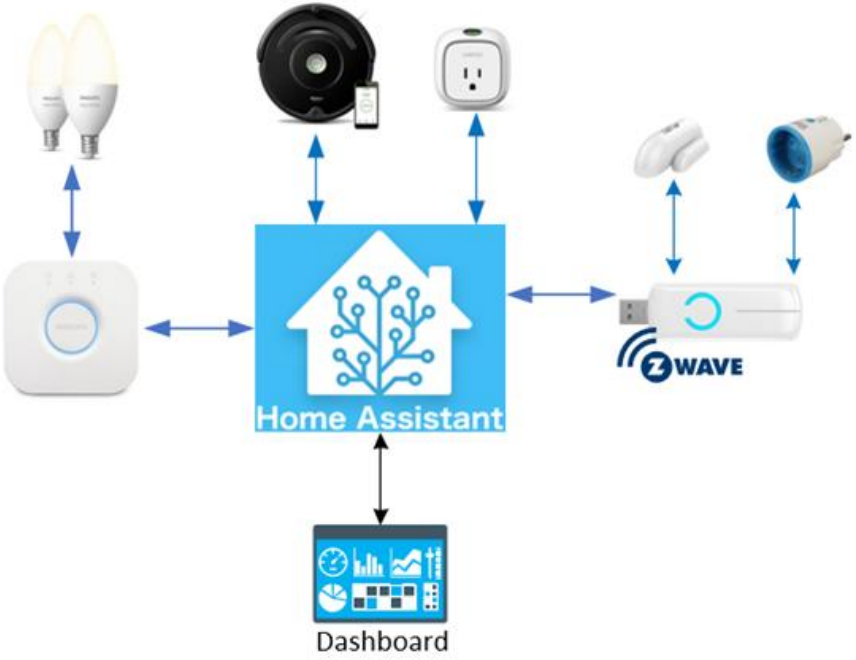
Automation in OT (example 2)



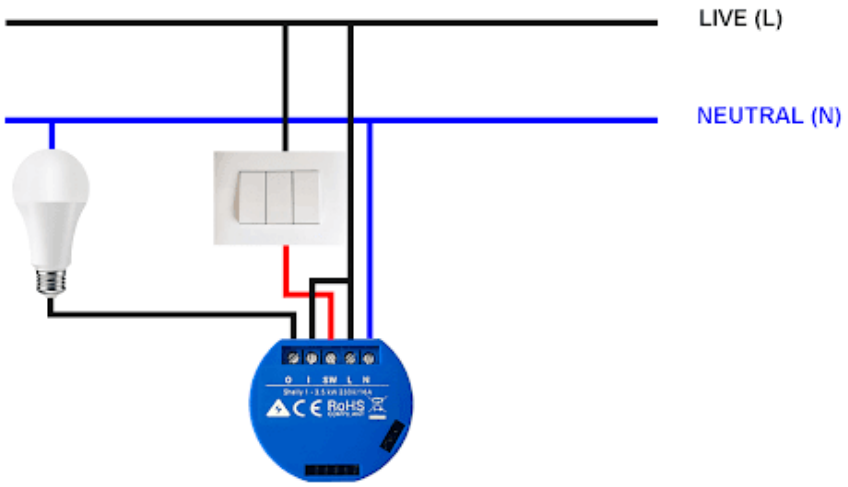
Home automation

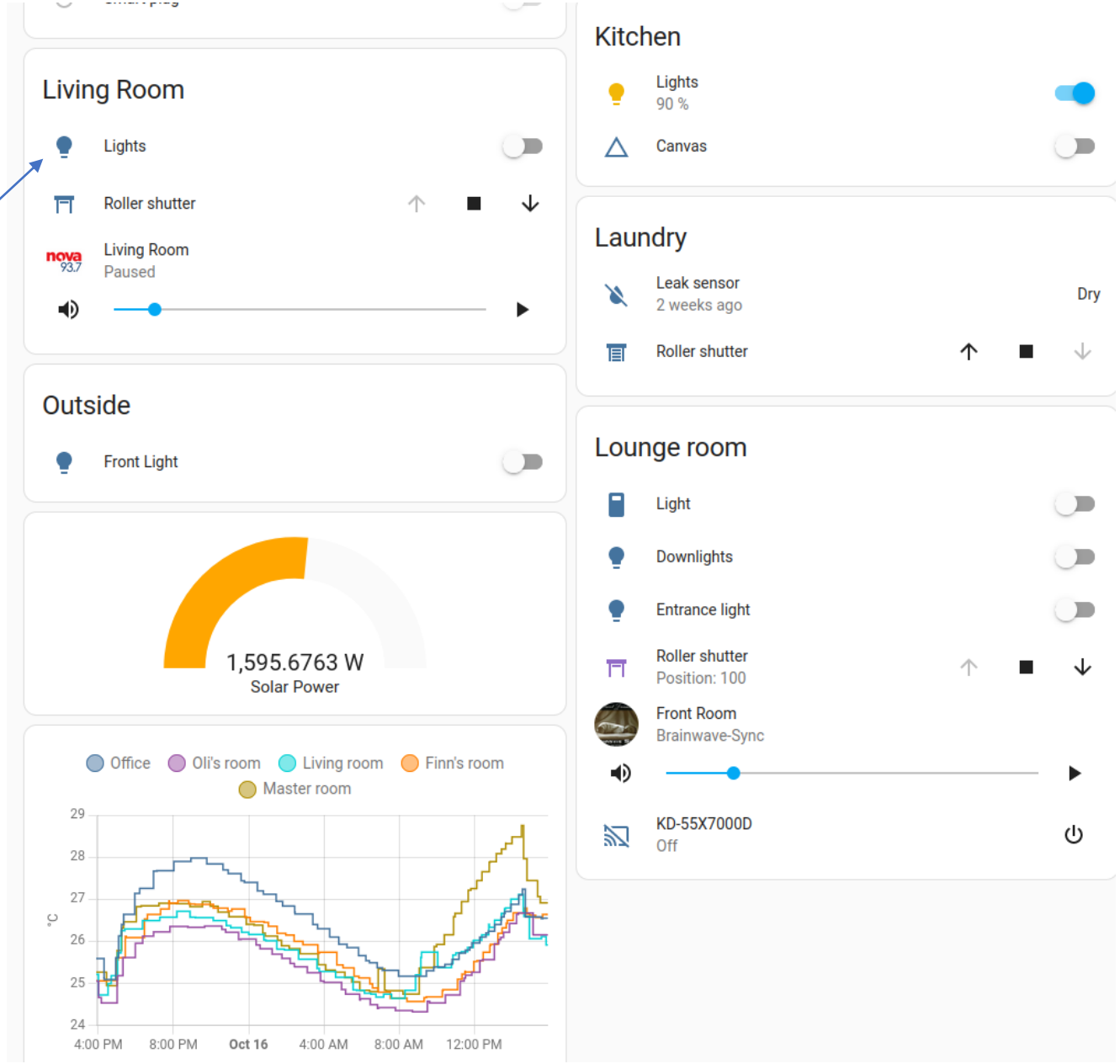
- •Specialist packages like Home Assistant or Node Red can automate IoT devices in homes.
- •These packages will use Python or Javascript for custom user modules.



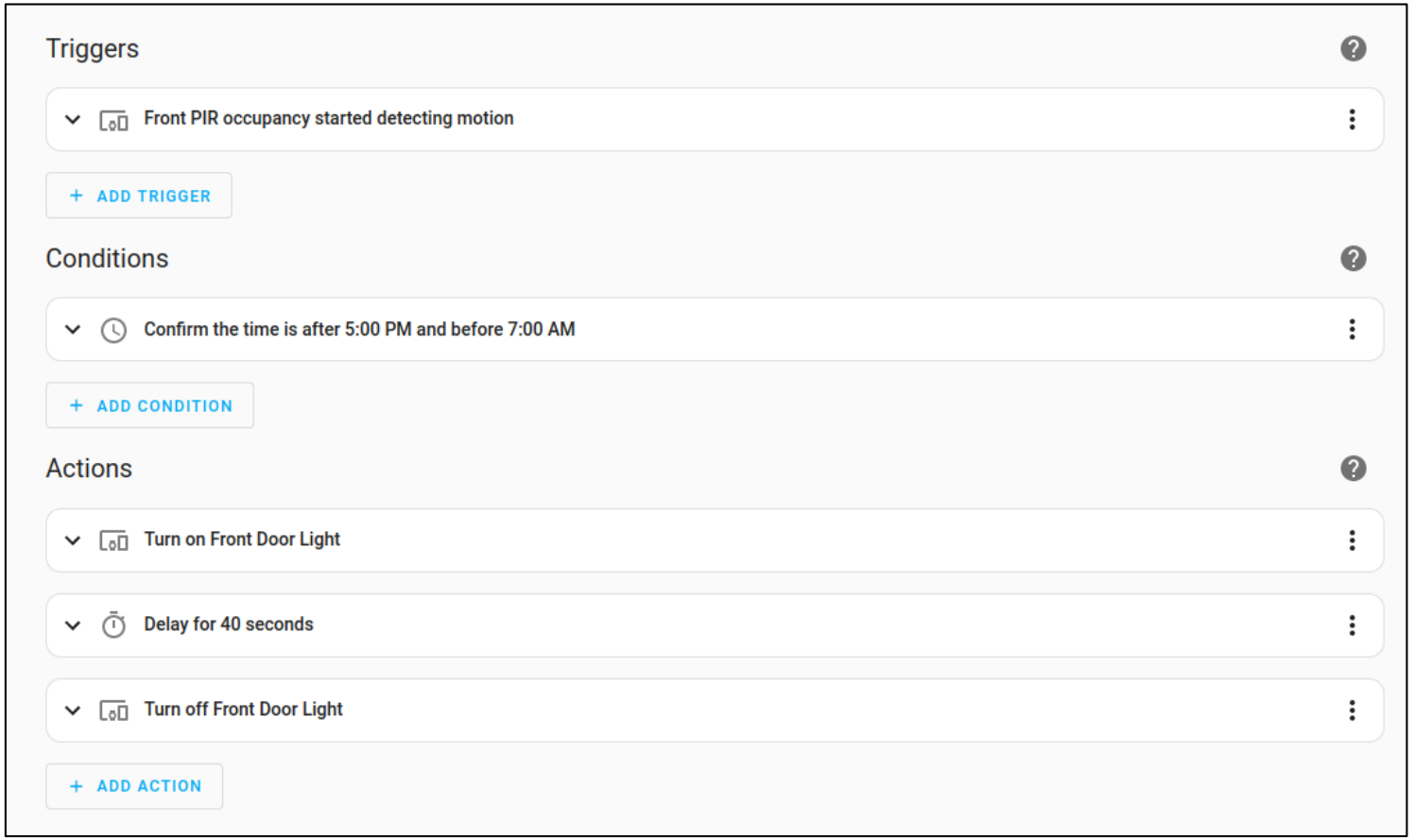


Home automation





Home automation




```yaml
alias: Front Light Motion sun
description: ""
trigger:
  - type: motion
    platform: device
    device_id: 5ccb7602a044ba03e56ba33b762c2a35
    entity_id: binary_sensor.front_pir_occupancy
    domain: binary_sensor
condition:
  - condition: time
    before: "07:00:00"
    after: "17:00:00"
    weekday:
      - mon
      - tue
      - wed
      - thu
      - fri
      - sat
      - sun
action:
  - type: turn_on
    device_id: 0714798bc4f59bd55e759c54bbd7ff65
    entity_id: light.front_door_light
    domain: light
    brightness_pct: 100
  - delay:
      hours: 0
      minutes: 0
      seconds: 40
      milliseconds: 0
  - type: turn_off
    device_id: 0714798bc4f59bd55e759c54bbd7ff65
    entity_id: light.front_door_light
    domain: light
mode: restart
```

Why Automate?

- Efficiency
- Cost savings
- Accuracy
- Consistency
- Productivity
- Safety

What can you automate?

- Anything.
- If there is a thing, there is a way.
- Python is very good at automating many things.

Python examples

- **File Operations**:
- Automating file downloads, uploads, or transfers.
- Renaming, organising, or processing files in bulk.
- Parsing and extracting data from text or CSV files.

- **Data Processing**:
- Data scraping and web crawling to extract information from websites.
- Data cleaning, transformation, and analysis using libraries like pandas.

Python examples

- **IoT (Internet of Things)**:
- Collecting and analysing data from IoT devices.
- Controlling and monitoring IoT devices remotely.

- **Network Operations**:
- Automating network device configurations and monitoring.
- Network services management and troubleshooting.

Python examples

- **Security and Compliance**:
- Automating security scans and vulnerability assessments.
- Compliance auditing and reporting.

- **Monitoring and Alerting**:
- Setting up automated monitoring systems to detect and respond to issues.
- Sending alerts via various channels when predefined conditions are met.

Legislation to consider

- **Bank Secrecy Act (BSA)**: BSA in the U.S. requires financial institutions to have AML programs in place to detect and report suspicious transactions. Automation in AML should comply with BSA regulations.
- **Data Privacy**: The Privacy Act includes the Australian Privacy Principles (APPs), which outline the requirements for handling personal information and ensuring privacy compliance.
- **Occupational Safety and Health Administration (OSHA) Regulations**: Automation in workplaces must comply with OSHA regulations to ensure workplace safety.

Collaboration platforms

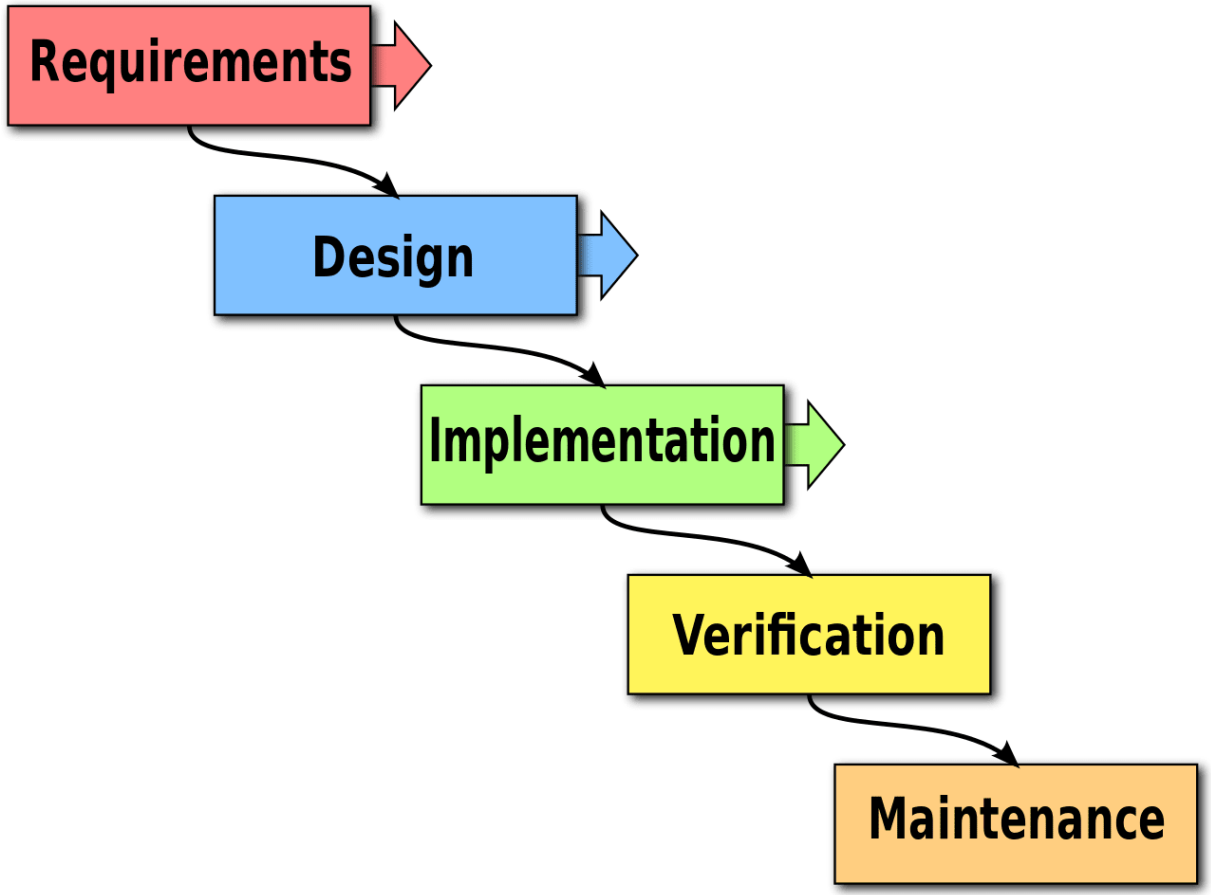
- Creating scripts or software will require:
  - Collaborating
  - Version control
  - Repository hosting
  - Issue tracking

- Go to live demo:
  - https://github.com/Koenkk/zigbee2mqtt

Software development models

- There are process to controlling how development may occur.
- Example process models include:
  - Waterfall
  - Agile
  - Scrum
  - Kanban

Waterfall


Requirements
Design
Implementation
Verification
Maintenance

What will you automate?

Go to BlackBoard example

Automation

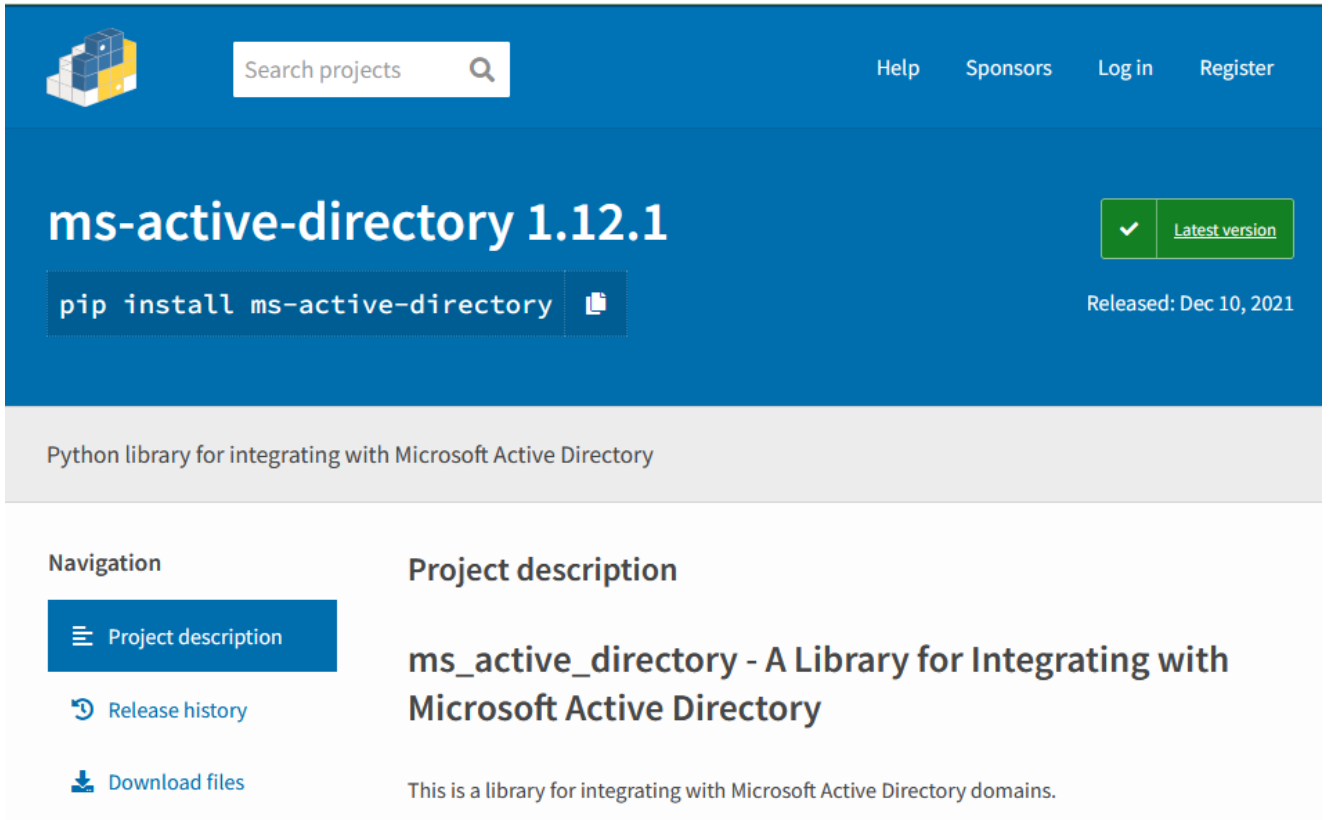
Automate with scripting

Automation using simple scripts

Use simple Python (or any other language) scripting to automate tasks.

Example 1 – User creation

- You can write Python scripts to automatically create new user accounts for an organisation.



https://pypi.org/project/ms-active-directory/

Example 2 – Archive script

- You can write Python scripts to automate archiving files.
- You can schedule those scripts to run at a desired time.

gistfile1.py Raw

```
import os
import glob
from datetime import date, timedelta
import re
from time import gmtime, strftime

folder = '<Insert folder name here>'
files = ['FileA.txt', 'FileB.txt']
archivePeriod = 5  # archive period in days

for file in files :
    try :
        # Remove file if older than archive period
        [fn, ff] = file.split('.')  # filename, fileformat
        for archivedFile in glob.glob(fn + "*" + ff):  # Find archived files
            matches = re.search(('(?<={}_)\d+(?=.txt)').format(fn), archivedFile)
            if  matches:
                if matches.group(0) < strftime('%Y%m%d' ,(date.today()-timedelta(days=archivePeriod)).timetuple()):
                    os.remove(os.path.join(dir, archivedFile))

        # Rename the file by appending last modified time stamp to the file name
        path = folder + file
        os.rename(path, path.replace('.txt', '_' + strftime('%Y%m%d', gmtime(os.path.getmtime(path))) + '.txt'))

    except FileNotFoundError :
        print ('File ' + path + ' was not found')
    except FileExistsError:
        print ('File ' + path.replace('.txt', '_' + strftime('%Y%m%d', gmtime(os.path.getmtime(path))) + '.txt') + ' already
```

https://gist.github.com/anderssonfilip/8955589

Automating OS functions in Linux

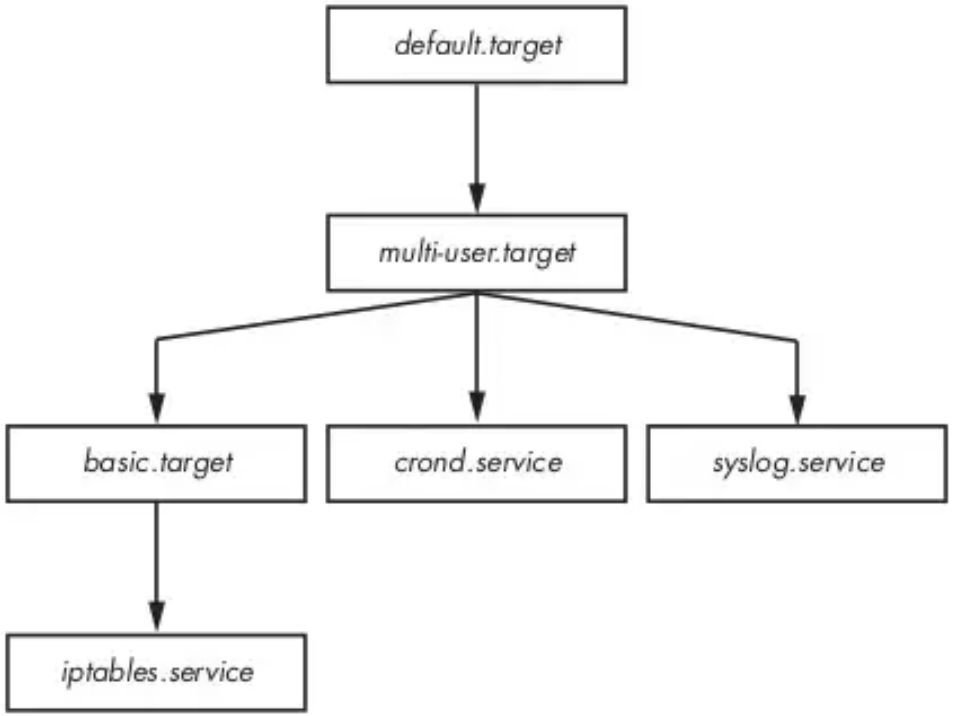
Linux uses systemd to automate the management of system services.

Example automation software – Systemd

- The systemd software and service manager is responsible for controlling how background tasks and software (services) are started, stopped and otherwise managed on Linux computers.
- Systemd uses a series of configuration “unit” files and scripts to automate and control how background tasks are started, stopped or scheduled in Linux.

https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/system_administrators_guide/chap-managing_services_with_systemd

Basic systemd flow



Systemd example

- Example steps to automate backup software running with systemd in Linux:
  1. Install the backup software.
  2. Configure the software (which files to backup and how).
  3. Write a systemd “unit” file to configure auto start up.

```
[Unit]
Description=Entering Time Machine
After=logRuin@user.service

[Service]
Type=simple
ExecStart=/bin/bash /root/Desktop/timeMachine.sh

[Install]
WantedBy=default.target
```

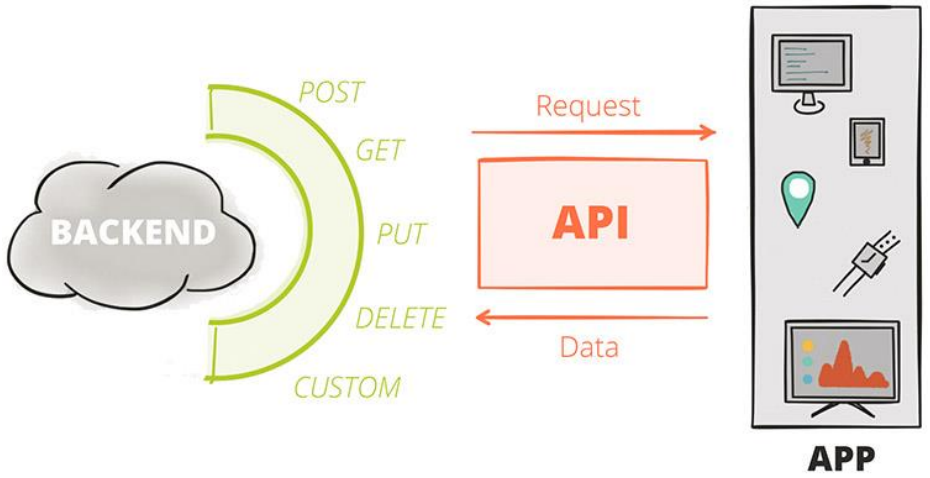
  4. Tell system to reload all “unit” files.

Automation protocols

How do these machines talk to each other?

API

- APIs are programable interfaces using common web protocols to automate the delivery and retrieval of data from devices or databases.
- API requests are sent by a client and a response is returned from a server using dictionaries and JSON.



API example

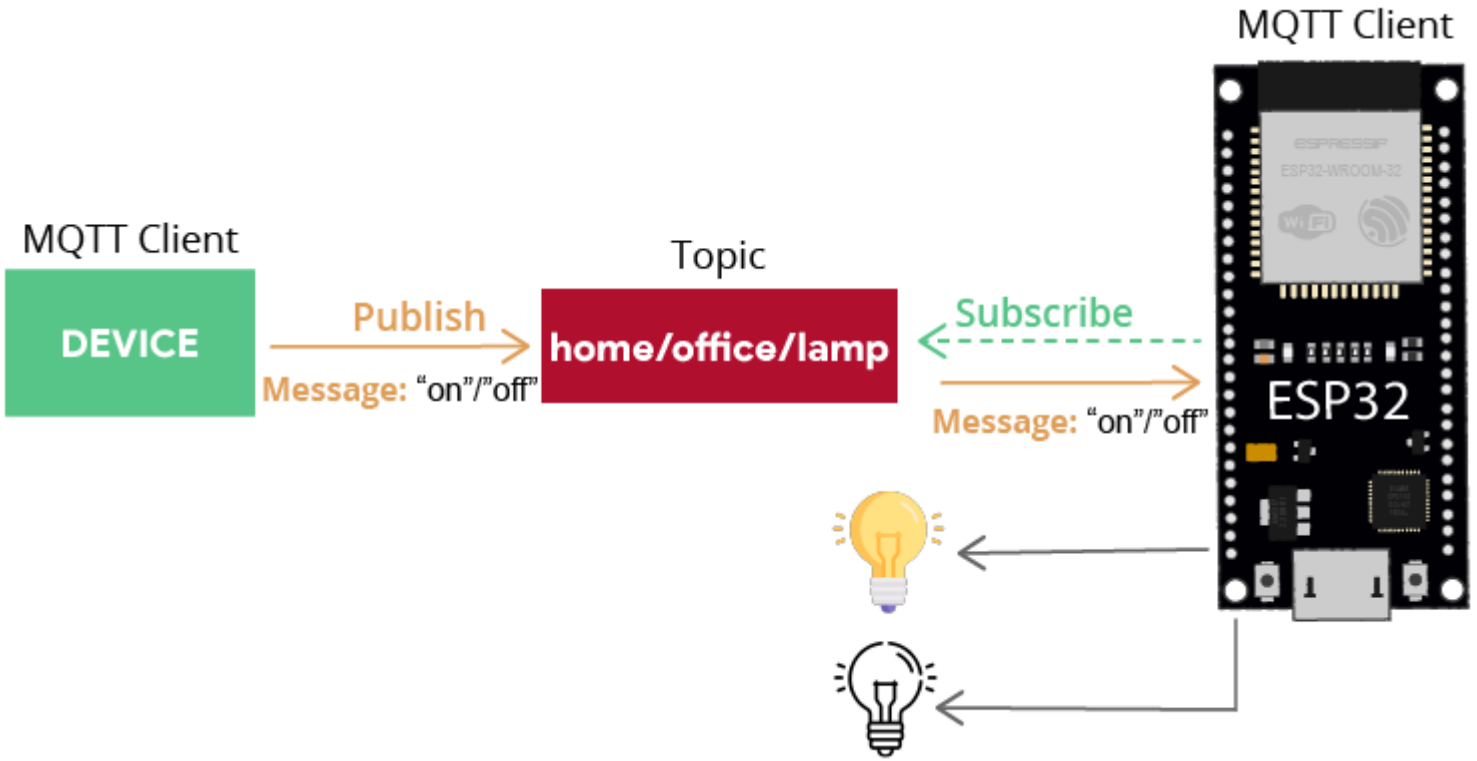
- Using an API to request the health of an elastic database cluster.
- The request returns a JSON dictionary that can be used to take further action.

```
s1access01:~ # curl 'http://localhost:9200/_cluster/health?pretty=true'
{
  "cluster_name" : "horizon",
  "status" : "yellow",
  "timed_out" : false,
  "number_of_nodes" : 2,
  "number_of_data_nodes" : 2,
  "active_primary_shards" : 50,
  "active_shards" : 67,
  "relocating_shards" : 0,
  "initializing_shards" : 0,
  "unassigned_shards" : 33,
  "delayed_unassigned_shards" : 33,
  "number_of_pending_tasks" : 0,
  "number_of_in_flight_fetch" : 0,
  "task_max_waiting_in_queue_millis" : 0,
  "active_shards_percent_as_number" : 67.0
}
s1access01:~ #
```

MQTT

- Many automation devices in IoT or OT will use a communication protocol called MQTT.
- MQTT is a simple extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices with a small code.
- MQTT uses a broker (server) to receive messages from publishers and then push those messages to subscribers.
- A publisher will publish a message to a topic on a broker. The subscribers listening to that topic will get that message.

MQTT



https://randomnerdtutorials.com/what-is-mqtt-and-how-it-works/

MicroPython

- Using simple cheap sensors and single board computers, anyone can automate tasks using Python.
- You can combine multiple devices with MQTT and automate anything.

```
import machine
import time

led= machine.Pin('LED', machine.Pin.OUT)

while (True):
    led.on()
    time.sleep(0.5)
    led.off()
    time.sleep(0.5)
```

https://projects.raspberrypi.org/en/projects/get-started-pico-w